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William P. Morse

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

VOL. XXXVIII—No. 8

PRESENTED TO
N. U. CIVIL
ENGINEERING SOCIETY
BY
WILLIAM P. MORSE

October, 1912

Published at the House of the Society, 220 West Fifty-seventh Street, New York, the Fourth Wednesday of each Month, except June and July.

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Entered as Second-Class Matter at the New York City Post Office, December 15th, 1896.
Subscription, $8 per annum.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

(INSTITUTED 1852)

VOL. XXXVIII—No. 8

OCTOBER, 1912

Edited by the Secretary, under the direction of the Committee on Publications.

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NEW YORK 1912

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◆

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day, and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER....................5913 Columbus.

CABLE ADDRESS....................."Ceas, New York."

Vol. XXXVIII. OCTOBER, 1912. No. 8.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PROCEEDINGS

This Society is not responsible for any statement made or opinion expressed in its publications.

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MINUTES OF MEETINGS

OF THE SOCIETY

September 18th, 1912.—The meeting was called to order at 8.30 P. M.; Director T. Kennard Thomson in the chair; Chas. Warren Hunt, Secretary; and present, also, 77 members and 6 guests.

A paper by C. L. Annan, M. Am. Soc. C. E., entitled "Street Sprinkling in St. Paul, Minn.," was presented by the Secretary, who also read a communication on the subject from S. Whinery, M. Am. Soc. C. E. The paper was discussed orally by Arthur H. Blanchard, M. Am. Soc. C. E.

The Secretary also presented a paper by W. C. Hammatt, M. Am. Soc. C. E., entitled "A Western Type of Movable Weir Dam," and the subject was discussed orally by T. C. Atwood, M. Am. Soc. C. E.

The Secretary announced the following deaths:

BENJAMIN MORGAN HARROD (*Past-President*), elected Member, April 4th, 1877; died September 7th, 1912.

Charles Lewis Harrison, elected Member, March 2d, 1898; died September 14th, 1912.

Joseph Allen Powers, elected Junior, April 2d, 1884; Member, September 3d, 1890; died September 1st, 1912.

Adjourned.

October 2d, 1912.—The meeting was called to order at 8.30 p. m.; Nelson P. Lewis, M. Am. Soc. C. E., in the chair; Chas. Warren Hunt, Secretary; and present, also, 175 members and 30 guests.

The minutes of the meeting of September 4th, 1912, were approved as printed in *Proceedings* for September, 1912.

Messrs. Kenneth Allen, Albert H. Dakin, Jr., and Albin G. Nicolaysen were appointed Tellers to canvass the ballot on the following proposed amendment to the Constitution:

"Strike out Article VII and substitute the following:

"ARTICLE VII.—Nomination and Election of Officers.

"1.—The Board of Direction shall, from time to time, divide the territory occupied by the membership into seven geographical districts, to be designated by numbers. District No. 1 shall be the territory within fifty miles of the Post Office in the City of New York. Each of the other districts shall be, as nearly as practicable, contiguous territory on State or Territorial lines; each shall contain, as nearly as practicable, an equal number of members, and they shall be designated as Districts Nos. 2, 3, 4, 5, 6, and 7. The Board shall announce such division to the Society on or before the first day of March in each year.

"2.—At the Annual Meeting of each year, seven Corporate Members, not officers of the Society, one from each of the geographical districts, shall be appointed by the meeting to serve for two years; who, with the seven members holding over and the five living last Past-Presidents of the Society, shall be a committee to nominate officers for the Society.

"The Board of Direction may prescribe the mode of procedure for appointing this committee, and fill any vacancies occurring.

"This committee shall meet at the Annual Convention of the Society, or at a time and place to be agreed upon by a majority of its members, but said meeting shall not be later than the fifteenth day of July. At this meeting this committee shall elect from among its members a Chairman and a Secretary to serve for one year beginning on the first day of the following September. At all meetings of the committee eight members shall constitute a quorum. If at any stated or called meeting of the committee there shall not be a quorum present, then such members as are present shall call an adjourned meeting for the transaction of the committee's business. This committee shall select nominees to fill the offices named in Article V, with the exception of the office of Secretary, so as to provide, with the officers holding over, a Vice-President and six Directors, residing in District No. 1, and twelve Directors divided equally, with regard to number and residence, among the remaining districts, Nos. 2, 3, 4, 5, 6, and 7.

In case any nominee or officer shall change his residence from one district to another, he shall continue to represent the district in which he resided when nominated. Nominations under this section shall be designated as 'Official Nominations.'

"A list of the nominees selected for the offices to be filled at the next Annual Election shall be presented by this committee to the Board of Direction not later than the first day of August, and the Secretary shall thereupon immediately notify each nominee of his nomination and ascertain his acceptance or declination.

"3.—Directly after the first day of October the aforesaid list of nominees shall be mailed to every Corporate Member whose address is known, provided that if any person shall be found by the Board of Direction to be ineligible for the office for which he is nominated, or should a nominee decline such nomination, his name shall not be sent out, but the Board shall substitute another name therefor, and further provided that in the event that the Nominating Committee fails to select a nominee for any office as above stipulated, the Board shall select a nominee therefor. The Board shall also fill any vacancies that may occur in this list of nominees up to the time the ballots are sent out. Vacancies shall be so filled as to preserve the geographical distribution of officers prescribed in Section 2 of this Article.

"4.—Additional nominations complying with Section 2 of this Article regarding the distribution of nominees among the several districts may be made by declaration, provided such declaration is accompanied by an acceptance of the nomination signed by the nominee, and is filed with the Secretary before the first day of December, and further provided that each declaration shall be signed by at least twenty-five Corporate Members. Nominations made in accordance with this Section shall be known as 'Nominations by Declaration.'

"5.—At least thirty days before the Annual Meeting there shall be mailed to every Corporate Member whose address is known a letter-ballot with envelopes for voting. This ballot shall include the names and residences of all persons nominated in accordance with this Article, the grades of membership, and, in the case of nominees for Directors, the number of the district in which they reside. Under the names of the nominees for each office so printed there shall be provided a space for the use of the voter if he desires to substitute another name. Nominations by Declaration shall be distinguished from Official Nominations by some convenient mark or words. There shall also be printed on the ballot the names of the Nominating Committee as created by Section 2 of this Article, with the numbers of the districts which the appointed members represent, and also in a separate list thereon the names and residences of the signers of each Nomination by Declaration.

"Voters may strike out the name of any nominee printed on the ballot for whom they do not wish to vote, and may substitute therefor, in writing or by paster, the name of any person eligible for the office; but the number of names voted for for any office shall not exceed the number of persons to be elected to such office. Ballots not complying with these provisions shall be rejected.

"Directions in accordance with these provisions shall be issued with the ballots.

"6.—Ballots may be sent by mail to the Secretary, or may be presented to him at the Society House. They should be enclosed in two sealed envelopes, and the outer envelope shall be endorsed by the voter's signature.

"The Secretary shall make a list of the voters from whom ballots are received, which list shall be open to inspection by all Corporate Members. A voter may withdraw his ballot, and may substitute another, at any time before the polls close.

"7.—The polls shall be closed at 9 A. M. on the first day of the Annual Meeting, and the ballots shall be canvassed publicly by tellers, who shall be appointed by the presiding officer.

"The persons who receive the largest number of votes for each office to be filled shall be declared elected.

"In case of a tie between two or more persons for the same office, the Annual Meeting shall elect the officer from among the persons so tied.

"The presiding officer shall announce to the meeting the names of the officers elected."

The Tellers reported as follows:

Total number of ballots received		734
Number of ballots received from Corporate Members not entitled to vote		19
Total number of ballots to be counted		715
Number of ballots in favor	680	
Number of ballots against	31	
Number of ballots blank	4	
Total	715	

Kenneth Allen,
Albert H. Dakin, Jr.,
Albin G. Nicolaysen.

The Chair declared the amendment carried.

A paper entitled "The Sixth Avenue Subway of the Hudson and Manhattan Railroad," by H. G. Burrowes, M. Am. Soc. C. E., was presented by the author, and illustrated with lantern slides. The paper was discussed orally by Messrs. William J. Boucher, Lazarus White, H. L. Oestreich, and the author. A written discussion by T. B. Whitney, Jr., M. Am. Soc. C. E., was presented by the Secretary.

The Secretary announced the election of the following candidates on October 1st, 1912:

As Members

George Lewis Bean, Philadelphia, Pa.
Thomas Rupe Beeman, Beverly, Wash.
Davenport Bromfield, San Mateo, Cal.
Edward Emery Carpenter, Victoria, B. C., Canada
George Thomas Forsyth, Kansas City, Mo.

James Josias Gaillard, Macon, Ga.
Samuel Gourdin Gaillard, Philadelphia, Pa.
William Herbert Gibson, Philadelphia, Pa.
Simon Henry Harrison, Ragland, Ala.
Joseph John Jessup, Berkeley, Cal.
Ray Messinger Murray, Spokane, Wash.
William Fullerton Reeves, New York City
William James Shackelford, Greenville, Miss.
Roland Aldrich Thayer, Greenville, S. C.
DeBerniere Whitaker, Santiago de Cuba, Cuba
Frederick Charles Wilson, Felton, Cuba
Herbert Alva Wilson, Boston, Mass.
James Albert Woodruff, Vicksburg, Miss.
Charles Colt Yates, Washington, D. C.

As Associate Members

William Frederick Alfred Anson, Rural Retreat, Va.
Ernest Daniel Bean, Medina, N. Y.
Robert Ernest Beaty, New York City
Henry Crist Benson, Tallulah Falls, Ga.
Gordon Byron Canaga, Manila, Philippine Islands
Elbert Milam Chandler, Burbank, Wash.
Jesse John Davy, Shakopee, Minn.
Newbold Drayton, Sand Patch, Pa.
Samuel Alexander Forter, Pratt, Kans.
William Strobridge Gelette, San Francisco, Cal.
Harry J Hanmer, Gloversville, N. Y.
George Stevens Hinckley, Redlands, Cal.
Albert Harrison Hinkle, Columbus, Ohio
Lewis Allen Jones, Washington, D. C.
Stanley Albert Kerr, Helena, Mont.
Jason Casimir LeDuke, Toledo, Ohio
Andrew Lenderink, Kalamazoo, Mich.
Walter Lawrence Lorah, Bourne, Mass.
Kern Wilson McHose, Wilkinsburg, Pa.
Charles William Martin, St. Louis, Mo.
Ernest Edward Meier, St. Louis, Mo.
Egmont Felix Mittmann, Wichita Falls, Tex.
Charles Moser, Palo Alto, Cal.
Edwin Randolph Page, Ansted, W. Va.
George Austin Quinlan, Chicago, Ill.
Joseph Warren Rogers, Shokan, N. Y.
James Selden Shute, Brooklyn, N. Y.
Walter Pearce Stine, Aguadulce, Panama
Robert August Strecker, Louisville, Ky.

Robert Summers Stronach, Westminster Junction, B. C., Canada
James Hiram Sturdevant, Watertown, N. Y.
Henry Taylor, Kenova, W. Va.
John Edward Thornton, Waco, Tex.
Arthur Carling Toner, Baltimore, Md.
Paul Page Whitham, Seattle, Wash.
Leslie Bateman Woodruff, Camden, N. J.

As Juniors

Harold Edward Akerly, Rochester, N. Y.
Earl Daniel Brown, Oakland, Cal.
Clement Edwards Chase, Toledo, Ohio
Clarence Westgate Cook, Los Angeles, Cal.
Carl Crandall, Ithaca, N. Y.
John Dubuis, Portland, Ore.
Charles Fischer, Jr., New Paltz, N. Y.
Ralph Edward Goodwin, New York City
Russell Platt Hastings, Palo Alto, Cal.
George Cleveland Haun, San Francisco, Cal.
Raymond Clark Hill, Pittsburgh, Pa.
Miles Cary Macon Johnston, Ithaca, N. Y.
Walter Harlan Leckliter, Manila, Philippine Islands
Gordon Grant MacLeish, Ithaca, N. Y.
Searle Brown Nevius, Oakland, Cal.
Elmer Alfred Porter, Salt Lake City, Utah
Augustin Mitchell Prentiss, Manila, Philippine Islands
Ralph Reginald Randell, Seattle, Wash.
Earnest Conrad Rohde, Jr., Boulder, Colo.
William Edward Rudolph, Brooklyn, N. Y.
James Ralph Shields, Berkeley, Cal.
Neil Thom, Jr., San Francisco, Cal.
Lem Seo Tsang, Troy, N. Y.
David Roswell Wylie, New York City

The Secretary announced the transfer of the following candidates on October 1st, 1912:

From Associate Member to Member

William James Backes, Hartford, Conn.
Howard Edward Boardman, Buenos Aires, Argentine Republic
Henry Lilburn Gray, Olympia, Wash.
Paul Evans Green, Chicago, Ill.
Alfred Hanson Hartman, Baltimore, Md.
George Eber Stratton, Helena, Mont.
Waldo Gilman Wildes, Rochester, N. Y.
Andrew Alfred Woods, Vicksburg, Miss.

From Junior to Associate Member

Nathaniel Townsend Blackburn, Galveston, Tex.
Kenneth Mackenzie Cameron, Ottawa, Ont., Canada
Lester Levi Carter, Los Angeles, Cal.
Francis Stirling Crowell, Albany, N. Y.
William Henry Dittoe, Columbus, Ohio
James Calvin Foss, Jr., Kahului, Hawaii
Robert Walter Gay, Agricultural College, Miss.
Wilder Meloy Rich, Grand Rapids, Mich.
Francis Rauch Schmid, New York City
Alfred Lockwood Trowbridge, San Francisco, Cal.
Earll Chase Weaver, Ashland, Ore.
Clement Clarence Williams, Chicago, Ill.
David Leroy Yarnell, Washington, D. C.

The Secretary announced the following deaths:

James Dix Schuyler, elected Member, December 6th, 1882; died September 13th, 1912.

Rowan Ayres, elected Associate Member, July 9th, 1912; died August 13th, 1912.

Adjourned.

OF THE BOARD OF DIRECTION

(Abstract)

October 1st, 1912.—Director Loomis in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Bush, Clarke, Endicott, Gerber, Kimball, Knap, Ridgway, and Snow.

Ballots for membership were canvassed, resulting in the election of 19 Members, 36 Associate Members, and 24 Juniors, and the transfer of 13 Juniors to the grade of Associate Member.

Eight Associate Members were transferred to the grade of Member.

Applications were considered and other routine business transacted.

Adjourned.

ANNOUNCEMENTS

The House of the Society is open from 9 A. M. to 10 P. M., every day, except Sundays, Fourth of July, Thanksgiving Day, and Christmas Day.

FUTURE MEETINGS

November 6th, 1912.—8.30 P. M.—A regular business meeting will be held, and two papers will be presented for discussion, as follows: "The Flood of March 22d, 1912, at Pittsburgh, Pa.," by Kenneth C. Grant, Assoc. M. Am. Soc. C. E.; and "State and National Water Laws, with Detailed Statement of the Oregon System of Water Titles," by John H. Lewis, Assoc. M. Am. Soc. C. E.

Mr. Grant's paper was printed in *Proceedings* for August, 1912, and Mr. Lewis' paper appeared in the September, 1912, *Proceedings.*

November 20th, 1912.—8.30 P. M.—At this meeting two papers will be presented for discussion, as follows: "The Sewickley Cantilever Bridge Over the Ohio River," by A. W. Buel, M. Am. Soc. C. E.; and "Ports of the Pacific," by H. M. Chittenden, M. Am. Soc. C. E., assisted by A. O. Powell, M. Am. Soc. C. E.

These papers were printed in *Proceedings* for September, 1912.

December 4th, 1912.—8.30 P. M.—This will be a regular business meeting. Two papers will be presented for discussion, as follows: "Tufa Cement, as Manufactured and Used on the Los Angeles Aqueduct," by J. B. Lippincott, M. Am. Soc. C. E.; and "The Economic Aspect of Seepage and Other Losses in Irrigation Systems," by E. G. Hopson, M. Am. Soc. C. E.

These papers are printed in this number of *Proceedings.*

LIST OF NOMINEES FOR THE OFFICES TO BE FILLED AT THE ANNUAL ELECTION, JANUARY 15th, 1913

The following list of nominees for the offices to be filled at the Annual Meeting, January 15th, 1913, received from the Nominating Committee, was presented to the Board of Direction at its meeting on September 3d, 1912. The list has already been mailed to all Corporate Members:

For President, to serve one year:

George F. Swain, Cambridge, Mass.

For Vice-Presidents, to serve two years:

J. Waldo Smith, New York City.
Charles H. Rust, Victoria, B. C., Canada.

For Treasurer, to serve one year:

John F. Wallace, New York City.

For Directors, to serve three years:

Henry W. Hodge, New York City	District No. 1
James H. Edwards, Passaic, N. J.	District No. 1
Leonard Metcalf, Boston, Mass.	District No. 2
Henry R. Leonard, Philadelphia, Pa.	District No. 4
Edward H. Connor, Leavenworth, Kans.	District No. 5
Samuel H. Hedges, Seattle, Wash.	District No. 7

SEARCHES IN THE LIBRARY

In January, 1902, the Secretary was authorized to make searches in the Library, upon request, and to charge therefor the actual cost to the Society for the extra work required. Since that time many searches have been made, and bibliographies and other information on special subjects furnished.

The resulting satisfaction, to the members who have made use of the resources of the Society in this manner, has been expressed frequently, and leaves little doubt that, if it were generally known to the membership that such work would be undertaken, many would avail themselves of it.

The cost is trifling compared with the value of the time of an engineer who looks up such matters himself, and the work can be performed quite as well, and much more quickly, by persons familiar with the Library.

In asking that such work be undertaken, members should specify clearly the subject to be covered, and whether references to general books only are desired, or whether a complete bibliography, involving search through periodical literature, is desired.

In reference to this work, the Appendices* to the Annual Reports of the Board of Direction for the years ending December 31st, 1906, and December 31st, 1910, contain summaries of all searches made to date.

PAPERS AND DISCUSSIONS

Members and others who take part in the oral discussions of the papers presented are urged to revise their remarks promptly. Written communications from those who cannot attend the meetings should be sent in at the earliest possible date after the issue of a paper in *Proceedings*.

All papers accepted by the Publication Committee are classified by the Committee with respect to their availability for discussion at meetings.

Papers which, from their general nature, appear to be of a character suitable for oral discussion, will be published as heretofore in

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* *Proceedings*, Vol. XXXIII, p. 20 (January, 1907); Vol. XXXVII, p. 28 (January, 1911).

Proceedings, and set down for presentation to a future meeting of the Society, and, on these oral discussions, as well as written communications, will be solicited.

All papers which do not come under this heading, that is to say, those which from their mathematical or technical nature, in the opinion of the Committee, are not adapted to oral discussion, will not be scheduled for presentation to any meeting. Such papers will be published in *Proceedings* in the same manner as those which are to be presented at meetings, but written discussions, only, will be requested for subsequent publication in *Proceedings* and with the paper in the volumes of *Transactions*.

LOCAL ASSOCIATIONS OF MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Association

The San Francisco Association of Members of the American Society of Civil Engineers holds regular bi-monthly meetings, with banquet, and weekly informal luncheons. The former are held at 6 P. M., at the Palace Hotel on the third Friday of February, April, June, August, October, and December, the last being the Annual Meeting of the Association.

Informal luncheons are held at 12.15 P. M. every Wednesday, and the place of meeting may be ascertained by communicating with the Secretary of the Association, E. T. Thurston, Jr., M. Am. Soc. C. E., 713 Mechanics' Institute, 57 Post Street.

The by-laws of the Association provide for the extension of hospitality to any member of the Society who may be temporarily in San Francisco, and any such member will be gladly welcomed as a guest.

Colorado Association

The meetings of the Colorado Association of Members of the American Society of Civil Engineers are held on the second Saturday of each month, except July and August. The hour and place of meeting are not fixed, but this information will be furnished on application to the Secretary, Gavin N. Houston, M. Am. Soc. C. E., 409 Equitable Building, Denver, Colo. The meetings are usually preceded by an informal dinner. Members of the American Society of Civil Engineers will be welcomed at these meetings.

Weekly luncheons are held on Wednesdays, and, until further notice, will take place at the Colorado Traffic Club.

Visiting members are urged to attend the meetings and luncheons.

Atlanta Association

On March 14th, 1912, the Atlanta Association of Members of the American Society of Civil Engineers was organized, with the following officers: Arthur Pew, President; William A. Hansell, Jr., Secretary; and Messrs. James N. Hazlehurst and Alexander Bonnyman, Members of the Executive Committee. The Association will hold its meetings in the house of the University Club.

PRIVILEGES OF ENGINEERING SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Members of the American Society of Civil Engineers will be welcomed by the following Engineering Societies, both to the use of their Reading Rooms and at all meetings:

American Institute of Mining Engineers, 29 West Thirty-ninth Street, New York City.

American Society of Mechanical Engineers, 29 West Thirty-ninth Street, New York City.

Architekten-Verein zu Berlin, Wilhelmstrasse 92, Berlin W. 66, Germany.

Associação dos Engenheiros Civis Portuguezes, Lisbon, Portugal.

Australasian Institute of Mining Engineers, Melbourne, Victoria, Australia.

Boston Society of Civil Engineers, 715 Tremont Temple, Boston, Mass.

Brooklyn Engineers' Club, 117 Remsen Street, Brooklyn, N. Y.

Canadian Society of Civil Engineers, 413 Dorchester Street, West, Montreal, Que., Canada.

Civil Engineers' Society of St. Paul, St. Paul, Minn.

Cleveland Engineering Society, Chamber of Commerce Building, Cleveland, Ohio.

Cleveland Institute of Engineers, Middlesbrough, England.

Dansk Ingeniorforening, Amaliegade 38, Copenhagen, Denmark.

Engineers' and Architects' Club of Louisville, Ky., 303 Norton Building, Fourth and Jefferson Streets, Louisville, Ky.

Engineers' Club of Baltimore, Baltimore, Md.

Engineers' Club of Minneapolis, 17 South Sixth Street, Minneapolis, Minn.

Engineers' Club of Philadelphia, 1317 Spruce Street, Philadelphia, Pa.

Engineers' Club of St. Louis, 3817 Olive Street, St. Louis, Mo.

Engineers' Club of Toronto, 96 King Street, West, Toronto, Ont., Canada.

Engineers' Society of Northeastern Pennsylvania, 302 Board of Trade Building, Scranton, Pa.

Engineers' Society of Pennsylvania, 219 Market Street, Harrisburg, Pa.

Engineers' Society of Western Pennsylvania, 2511 Oliver Building, Pittsburgh, Pa.

Institute of Marine Engineers, 58 Romford Road, Stratford, London, E., England.

Institution of Engineers of the River Plate, Buenos Aires, Argentine Republic.

Institution of Naval Architects, 5 Adelphi Terrace, London, W. C., England.

Junior Institution of Engineers, 39 Victoria Street, Westminster, S. W., London, England.

Koninklijk Instituut van Ingenieurs, The Hague, The Netherlands.

Louisiana Engineering Society, 321 Hibernia Bank Building, New Orleans, La.

Memphis Engineering Society, Memphis, Tenn.

Midland Institute of Mining, Civil and Mechanical Engineers, Sheffield, England.

Montana Society of Engineers, Butte, Mont.

North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne, England.

Oesterreichischer Ingenieur- und Architekten-Verein, Eschenbachgasse 9, Vienna, Austria.

Pacific Northwest Society of Engineers, 803 Central Building, Seattle, Wash.

Rochester Engineering Society, Rochester, N. Y.

Sachsischer Ingenieur- und Architekten-Verein, Dresden, Germany.

Sociedad Colombiana de Ingenieros, Bogota, Colombia.

Sociedad de Ingenieros del Peru, Lima, Peru.

Societe des Ingenieurs Civils de France, 19 Rue Blanche, Paris, France.

Society of Engineers, 17 Victoria Street, Westminster, S. W., London, England.

Svenska Teknologforeningen, Brunkebergstorg 18, Stockholm, Sweden.

Tekniske Forening, Vestre Boulevard 18–1, Copenhagen, Denmark.

Western Society of Engineers, 1737 Monadnock Block, Chicago, Ill.

ACCESSIONS TO THE LIBRARY

(From September 4th to October 3d, 1912)

DONATIONS*

ELEVATOR SHAFT CONSTRUCTION.

Or, Practical Suggestions for the Installation of Electric Elevators in Buildings. By H. Robert Cullmer, Assisted by Albert Bauer. Cloth, 9¾ x 6¾ in., illus., 174 pp. New York, The William T. Comstock Company, 1912. $3.00.

The principal purpose of this book, it is stated, is to emphasize the necessity of the co-operation of all parties connected with the work of elevator shaft construction and elevator installation, in order to produce the best results and the necessary economy. The subject-matter is said to cover every detail of elevator shaft construction, from the preparation of the drawings to the installation of the machinery, for elevators of various kinds. The articles on elevator shaft doors and machine rooms are said to contain information which will be especially useful to the architect in the preparation of plans, and, because of the difficulty of the problem involved, the article on the height of the elevator shaft bulkhead is detailed, the plates used for illustration conforming to the requirements of existing municipal regulations. Two forms of specifications for elevator equipment, one a simple one for a single door and the other for cars suitable for office buildings, have been included. A chapter has been devoted to the rules and regulations in regard to elevator installations, of New York City, and the author has also made a comparison with similar regulations in use in other cities. The Contents are: Elevator Shafts; Specifications for Elevator Work; Door Opening Devices and Elevator Car Gates; Elevator Signal Systems and Special Appliances; Rules and Regulations Governing Elevator Installation in New York City; Index.

ARTISTIC BRIDGE DESIGN.

A Systematic Treatise on the Design of Modern Bridges According to Aesthetic Principles. By Henry Grattan Tyrrell. With an Introduction by Thomas Hastings. Cloth, 9¼ x 6¼ in., illus., 16 + 294 pp. Chicago, The Myron C. Clark Publishing Co., 1912. $3.00.

In his preface the author states that very little attention has been given by American engineers to the artistic character of bridges, their proper proportions, and the selection of economic types. As far as the purely constructive features are concerned, almost all the problems have been solved, and it is hoped that the engineer of the Twentieth Century will insist upon and establish a higher standard of artistic treatment. This book, the subject-matter of which is a development of a series of articles on the subject first published in *The American Architect*, in 1901, is said to be the first systematic attempt made in the United States to apply the economic to the artistic in bridge design. In it the author gives his reasons why bridges should be ornamental and why they are not, and shows by many illustrations and descriptions how to construct them artistically, stating that as the lack of art in bridge design is due partly to the dearth of literature on the subject and the difficulty of securing good illustrations, he hopes the book will be of some help in producing better results in the future. The Chapter headings are: Importance of Bridges; Reasons for Art in Bridges; Standards of Art in Bridges; Causes for Lack of Art; Special Features of Bridges; Principles of Design; Ordinary Steel Structures; Cantilever Bridges; Metal Arches; Suspension Bridges; Masonry Bridges; Illustrations and Descriptions; Index.

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Primer of Scientific Management. By Frank B. Gilbreth. With an Introduction by Louis D. Brandeis. D. Van Nostrand Company, New York, 1912.

Mills' Irrigation Manual for Lawyers, Irrigation Officers, Engineers and Water Users: Being a Treatise on the Law of Irrigation, Together with the Statutes and Forms of Seventeen States and Territories. By J. Warner Mills. The Mills Publishing Co., Denver, 1907.

Central Station Heating. By Byron T. Gifford. Heating and Ventilating Magazine Co., New York, 1912.

A Text-Book of Rand Metallurgical Practice, Designed as a Working Tool and Practical Guide for Metallurgists upon the Witwatersrand and Other Similar Fields. By Ralph Stokes and others. Vol. 1. J. B. Lippincott, Philadelphia; Charles Griffin & Co., Ltd., London, 1911.

Reports of Decisions of the Public Service Commission, First District of the State of New York. 2 Vol. v. 1, July 1st, 1907-Sept. 1st, 1909; v. 3, Feb. 1st, 1912 to Aug. 1st, 1912. Public Service Commission, First District, New York, 1912.

Proceedings of the Twenty-third Annual Convention of the National Association of Railway Commissioners: Digest of Decisions of the Federal and State Courts, Interstate Commerce Act, Safety Appliance Acts, Arbitration Act, etc.: Compilation of the Laws of the States Pertaining to Railways and Other Public Service Corporations. Comp. by Herman B. Meyers. Traffic Service Bureau, Chicago and Washington, 1912.

An Introduction to the Theory of Statistics. By G. Udny Yule. Second Edition, Revised. J. B. Lippincott Co., Philadelphia; Charles Griffin and Co., Ltd., London, 1912.

The Refrigerating Engineer's Pocket Manual. By Oswald Gueth. New York, 1908.

Proceedings of the International Association for Testing Materials: Vol. 2, Nos. 11-12. Vienna, July, 1912.

The Human Factor in Works Management. By James Hartness. McGraw-Hill Book Company, New York and London, 1912.

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Dann, Alexander William. Fitler, Miss.

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JUNIORS

Alderman, Ernest Samuel. Care, U. S. Dept. of Agri., Office of Public Rds., Washington, D. C.

Battie, Herbert Scandlin. 332 Seventh Ave., S. W., Roanoke, Va.

Beall, Pendleton. Instrumentman, N. Y. C. & H. R. R. R., Ravena, N. Y.

JUNIORS (*Continued*)

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Winans, Lawrence Lewis. U. S. Office of Public Rds., Washington, D. C.

REINSTATEMENTS

JUNIORS	Date of Reinstatement.
Lake, Orloff	Sept. 3, 1912

RESIGNATIONS

MEMBERS	Date of Resignation.
Souther, Henry	Sept. 3, 1912
ASSOCIATES	
Anderson, Robert	Sept. 3, 1912
JUNIORS	
Borland, Bruce	July 18, 1912
Brown, Arthur Robert	Sept. 3, 1912

DEATHS

Ayres, Rowan. Elected Associate Member, July 9th, 1912; died August 13th, 1912.

Harrison, Charles Lewis. Elected Member, March 2d, 1898; died September 14th, 1912.

Harrod, Benjamin Morgan. (*Past-President*). Elected Member, April 4th, 1877; died September 7th, 1912.

Powers, Joseph Allen. Elected Junior, April 2d, 1884; Member, September 3d, 1890; died September 1st, 1912.

Schuyler, James Dix. Elected Member, December 6th, 1882; died September 13th, 1912.

Total Membership of the Society, October 3d, 1912, 6 671

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST

(September 6th to October 2d, 1912)

NOTE.—*This list is published for the purpose of placing before the members of this Society, the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS

In the subjoined list of articles, references are given by the number prefixed to each journal in this list:

(1) *Journal*, Assoc. Eng. Soc., Boston, Mass., 30c.
(2) *Proceedings*, Engrs. Club of Phila., Philadelphia, Pa.
(3) *Journal*, Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal*, Western Soc. of Engrs., Chicago, Ill., 50c.
(5) *Transactions*, Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly*, Columbia Univ., New York City, 50c.
(7) *Gesundheits Ingenieur*, München, Germany.
(8) *Stevens Institute Indicator*, Hoboken, N. J., 50c.
(9) *Engineering Magazine*, New York City, 25c.
(10) *Cassier's Magazine*, New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News*, New York City, 15c.
(14) *The Engineering Record*, New York City, 10c.
(15) *Railway Age Gazette*, New York City, 15c.
(16) *Engineering and Mining Journal*, New York City, 15c.
(17) *Electric Railway Journal*, New York City, 10c.
(18) *Railway and Engineering Review*, Chicago, Ill., 15c.
(19) *Scientific American Supplement*, New York City, 10c.
(20) *Iron Age*, New York City, 20c.
(21) *Railway Engineer*, London, England, 1s. 2d.
(22) *Iron and Coal Trades Review*, London, England, 6d.
(23) *Bulletin*, American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal*, New York City, 10c.
(25) *American Engineer*, New York City, 20c.
(26) *Electrical Review*, London, England, 4d.
(27) *Electrical World*, New York City, 10c.
(28) *Journal*, New England Water-Works Assoc., Boston, Mass., $1.
(29) *Journal*, Royal Society of Arts, London, England, 6d.
(30) *Annales des Travaux Publics de Belgique*, Brussels, Belgium, 4 fr.
(31) *Annales* de l'Assoc. des Ing. Sortis des Ecoles Spéciales de Gand, Brussels, Belgium, 4 fr.
(32) *Mémoires et Compte Rendu des Travaux*, Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil*, Paris, France, 1 fr.
(34) *Portefeuille Economiques des Machines*, Paris, France.
(35) *Nouvelles Annales de la Construction*, Paris, France.
(36) *Cornell Civil Engineer*, Ithaca, N. Y.
(37) *Revue de Mécanique*, Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways*, Paris, France.
(39) *Technisches Gemeindeblatt*, Berlin, Germany, 0,70 m.
(40) *Zentralblatt der Bauverwaltung*, Berlin, Germany, 60 pfg.
(41) *Elektrotechnische Zeitschrift*, Berlin, Germany.
(42) *Proceedings*, Am. Inst. Elec. Engrs., New York City, $1.
(43) *Annales des Ponts et Chaussées*, Paris, France.
(44) *Journal*, Military Service Institution, Governors Island, New York Harbor, 50c.
(45) *Mines and Minerals*, Scranton, Pa., 25c.
(46) *Scientific American*, New York City, 15c.
(47) *Mechanical Engineer*, Manchester, England, 3d.
(48) *Zeitschrift*, Verein Deutscher Ingenieure, Berlin, Germany, 1,60 m.
(49) *Zeitschrift für Bauwesen*, Berlin, Germany.
(50) *Stahl und Eisen*, Düsseldorf, Germany.
(51) *Deutsche Bauzeitung*, Berlin, Germany.
(52) *Rigasche Industrie-Zeitung*, Riga, Russia, 25 kop.
(53) *Zeitschrift*, Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria, 70h.

(54) *Transactions,* Am. Soc. C. E., New York City, $4.
(55) *Transactions,* Am. Soc. M. E., New York City, $10.
(56) *Transactions,* Am. Inst. Min. Engrs., New York City, $6.
(57) *Colliery Guardian,* London, England, 5d.
(58) *Proceedings,* Engrs.' Soc. W. Pa., 803 Fulton Bldg., Pittsburgh, Pa., 50c.
(59) *Proceedings,* American Water Works Assoc., Troy, N. Y.
(60) *Municipal Engineering,* Indianapolis, Ind., 25c.
(61) *Proceedings,* Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *Industrial World,* 59 Ninth St., Pittsburgh, Pa., 10c.
(63) *Minutes of Proceedings,* Inst. C. E., London, England.
(64) *Power,* New York City, 5c.
(65) *Official Proceedings,* New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting,* London, England, 6d.
(67) *Cement and Engineering News,* Chicago, Ill., 25c.
(68) *Mining Journal,* London, England, 6d.
(69) *Der Eisenbau,* Leipzig, Germany.
(70) *Engineering Review,* New York City, 10c.
(71) *Journal,* Iron and Steel Inst., London, England.
(71*a*) *Carnegie Scholarship Memoirs,* Iron and Steel Inst., London, England.
(73) *Electrician,* London, England, 18c.
(74) *Transactions,* Inst. of Min. and Metal., London, England.
(75) *Proceedings,* Inst. of Mech. Engrs., London, England.
(76) *Brick,* Chicago, Ill., 10c.
(77) *Journal,* Inst. Elec. Engrs., London, England, 5s.
(78) *Beton und Eisen,* Vienna, Austria, 1,50m.
(79) *Forscherarbeiten,* Vienna, Austria.
(80) *Tonindustrie Zeitung,* Berlin, Germany.
(81) *Zeitschrift für Architektur und Ingenieurwesen,* Wiesbaden, Germany.
(83) *Progressive Age,* New York City, 15c.
(84) *Le Ciment,* Paris, France.
(85) *Proceedings,* Am. Ry. Eng. Assoc., Chicago, Ill.
(86) *Engineering-Contracting,* Chicago, Ill., 10c.
(87) *Railway Engineering and Maintenance of Way,* Chicago, Ill., 10c.
(88) *Bulletin* of the International Ry. Congress Assoc., Brussels, Belgium.
(89) *Proceedings,* Am. Soc. for Testing Materials, Philadelphia, Pa., $5.
(90) *Transactions,* Inst. of Naval Archts., London, England.
(91) *Transactions,* Soc. Naval Archts. and Marine Engrs., New York City.
(92) *Bulletin,* Soc. d'Encouragement pour l'Industrie Nationale, Paris, France.
(93) *Revue de Métallurgie,* Paris, France, 4 fr. 50.
(94) *The Boiler Maker,* New York City, 10c.
(95) *International Marine Engineering,* New York City, 20c.
(96) *Canadian Engineer,* Toronto, Ont., Canada, 10c.
(98) *Journal,* Engrs. Soc. Pa., Harrisburg, Pa., 30c.
(99) *Proceedings,* Am. Soc. of Municipal Improvements, New York City, $2.
(100) *Professional Memoirs,* Corps of Engrs., U. S. A., Washington, D. C., 50c.
(101) *Metal Worker,* New York City, 10c.
(102) *Organ für die Fortschritte des Eisenbahnwesens,* Wiesbaden, Germany.
(103) *Mining and Scientific Press,* San Francisco, Cal., 10c.
(104) *The Surveyor and Municipal and County Engineer,* London, England, 6d.
(105) *Metallurgical and Chemical Engineering,* New York City, 25c.
(106) *Transactions,* Inst. of Mining Engrs., London, England, 6s.
(107) *Schweizerische Bauzeitung,* Zürich, Switzerland.
(108) *Southern Machinery,* Atlanta, Ga., 10c.

LIST OF ARTICLES

Bridges.

Report of Sub-Committee of the Am. Ry. Eng. Assoc. on Impact Tests.* (85) Vol. 12, Pt. 3.

Report of Committee 7 of the Am. Ry. Eng. Assoc. on Wooden Bridges and Trestles.* (85) Vol. 12, Pt. 1; Vol. 13.

The Design of Railway Bridge Abutments.* J. H. Prior. (Paper read before the Am. Ry. Eng. Assoc.) (85) Vol. 13.

Specifications for the Erection of Railroad Bridges. (Report of Committee, Am. Ry. Eng. Assoc.) (85) Vol. 12, Pt. 3; Vol. 13.

On the Greatest Bending Moment Produced by Cooper's E-40 Loading.* W. H. Schuerman. (85) Vol. 12, Pt. 3.

Arch Design; Specialization and Patents.* Daniel B. Luten. (4) Sept.

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*Illustrated.

Bridges—(Continued).

Bridge Foundations in the Columbia and Willamette Rivers near Portland, Oregon. Ralph Modjeski, M. Am. Soc. C. E. (Paper read before the Oregon Soc. of Engrs.) (1) Sept.
Notes on the Design of Girder and Truss Spans and Trestle Work in Structural Steel. F. W. Dencer. (Paper read before the Eng. Soc. of Valparaiso Univ.) (86) Sept. 4.
Some Notes on the Oakville Viaduct and the Dynamiting of the Condemned Arch Ribs, August 12, 1912.* C. H. Cunningham. (96) Sept. 5.
Decorative Treatment of a Bridge over a Chicago Boulevard.* (13) Sept. 5.
Rebuilding a Bridge Pier in a Cofferdam.* (14) Sept. 7.
The Calcutta-Howrah Floating Bridge.* (12) Sept. 13.
Electrically Operated Bascule Bridges, the Heel Trunnion Type.* (19) Sept. 14.
The Hemlocks Concrete Masonry Dam at Bridgeport, Connecticut.* (14) Sept. 14.
A Temporary Bridge Over the Passaic River, Newark.* (14) Sept. 14.
Method of Constructing the Center for a 230-ft. Masonry Arch Built at Constantine, Algeria. (86) Sept. 18.
Highway Bridges and Culverts.* C. H. Hoyt. (Abstract of *Bulletin 43*, U. S. Office of Public Roads.) (104) Sept. 20.
Razing and Erecting Through Truss Bridges with an American Ditcher.* R. P. Black. (15) Sept. 20.
An Automatic Bumper for Drawbridges.* (17) Sept. 21.
Novel Bridge Erection in Santo Domingo.* (14) Sept. 21.
A Temporary Single-Track Bascule Span.* (14) Sept. 21.
Electrical Equipment for a Bascule Bridge.* C. H. Norwood. (15) Sept. 27.
Note au Sujet de la Reconstruction du Pont de la Route Nationale No. 5 sur l'Oued-Harrach à Maison-Carrée.* Butavand. (43) July.
Les Ponts de Constantine, Pont Suspendu de Sidi M'Cid.* Boisnier. (43) July.
Etude de la Solidarité des Pièces de Pont.* Henry Lossier. (33) Aug. 24.
La Ligne D'Andelot à la Cluse par Morez et Sainte-Claude (Jura).* Maurice Honoré. (33) Sept. 14.
Untersuchungen des Vereines deutscher Brücken- und Eisenbaufabriken mit Eisenkonstruktionen für den Brückenbau.* B. Stock. (48) July 13.
Beiträge zur Berechnung von Bogendächern.* F. Kögler. (69) Aug.
Die Bogenbrücke über den St. Croix-Fluss.* K. A. Müllenhoff. (69) Aug.
Eisenbahnbrücke über den Südarm des Sanagastromes in Deutsch-Kamerun.* F. Brunner. (69) Serial beginning Aug.
Ueber Eisenbeton-Vorschriften (Bridges).* (107) Aug. 10.
Der Brückenkanal des Grossschiffahrtweges Berlin-Stettin über der Berlin-Stettiner Eisenbahn.* Haesler. (40) Aug. 17.
Tabellen für Strassenbrücken aus einbetonierten Walzträgern.* Otto Kommerell. (40) Aug. 28.

Electrical.

Report of Committee 16 of the Am. Ry. Eng. Assoc. on Electricity.* (85) Vol. 13.
High-Voltage Tests and Energy Losses in Insulating Materials.* E. H. Rayner. (77) July.
The Supply and Transmission of Power in Self-Contained Road Vehicles and Locomotives.* J. C. Macfarlane and H. Burge. (77) July.
Tariffs for Electrical Energy with Particular Reference to Domestic Tariffs.* W. W. Lackie. (77) July.
A Simple Graphical Construction for Determining the Efficiency of a Polyphase Asynchronous Motor from the Current (Circle) Diagram.* John Nicholson. (77) July.
The Tungsten Filament Lamp on Alternating Current.* Lancelot W. Wild. (77) July.
Power Station Working.* J. W. Jackson. (77) July.
High-Tension Porcelain Line Insulators.* (77) July.
A Portable Electrical Instrument for the Detection of Combustible Gases and Vapours in Air.* Louis J. Steele. (77) July.
Street Lighting. J. M. Bryant and H. G. Hare. (From *Bulletin*, Eng. Exper. Station, Univ. of Illinois.) (10) Aug.
Cost of Isolated Plant Power.* Paul A. Bancel. (98) Aug.
120-Ton Electric Travelling Crane.* (12) Aug. 30.
Electricity in Construction Work.* (73) Aug. 30.
Transforming Stations of Niagara Electrochemical and Electrometallurgical Industries. A. J. Jones. (Paper read before the Am. Electrochemical Soc.) (73) Aug. 30.
Electricity Supply in Sheffield.* (26) Serial beginning Aug. 30.
New Electrical Generating Station at Britannia Works, Middlesbrough.* (12) Aug. 30.
The Electrical Precipitation of Suspended Matter in Gases.* W. W. Strong. (3) Sept.
Street Lighting in Toronto, Ontario.* K. L. Aitken. (27) Sept. 7.
Keokuk-St. Louis Transmission Line.* (27) Sept. 7.

*Illustrated.

Electrical—(Continued).

Radiant Efficiency of the Carbon Arc Lamp.* William H. Damon and William J. Enders. (27) Sept. 7.

Control of Small Electric Furnaces. Charles Burton Thwing. (Paper read before the Inter. Congress for Applied Chemistry.) (105) Sept. 12.

The Scientific Theory and Outstanding Problems of Wireless Telegraphy.* J. A. Fleming. (Paper read before the British Assoc.) (11) Sept. 13; (26) Sept. 13; (73) Sept. 13.

The Production of Electrical Oscillations by Spark-Gaps Immersed in Running Liquids.* H. W. Eccles and A. J. Makower. (Paper read before the British Assoc.) (11) Sept. 13; (73) Sept. 13.

Norwich Electricity Works and the Flood.* (26) Sept. 13.

A Magnetic Shunt Vibration Galvanometer. Henry Tinsley. (73) Sept. 13.

The Féry Bomb Calorimeter.* Robert S. Whipple. (Paper read before the British Assoc.) (73) Sept. 13; (11) Sept. 20.

The Vibrations of Telephone Diaphragms.* Charles F. Meyer and J. B. Whitehead. (19) Serial beginning Sept. 14.

Electrical Features of Some Chicago Office Buildings.* (27) Sept. 14.

The Impedance of Telephone Receivers as Affected by the Motion of Their Diaphragms.* A. E. Kennelly and G. W. Pierce. (27) Sept. 14; (26) Sept. 13; (73) Sept. 13.

The Hysteresis Loss in Iron Due to a Combined Pulsating and Rotating Magnetic Field.* Thomas F. Wall. (Paper read before the British Assoc.) (73) Sept. 20.

The Quartz Mercury Vapor Lamp.* (73) Sept. 20.

The Use of Mica in the Insulation of Electrical Apparatus. A. P. M. Fleming and R. Johnson. (26) Serial beginning Sept 20.

Some Unique Electromagnets.* (From *Electrical Review and Western Electrician.*) (47) Sept. 20.

Characteristics of Metal Filaments.* Daniel H. Ogley. (26) Sept. 20.

Electricity in Harper Memorial Library.* (27) Sept. 21.

Minimizing Sparking in Direct-Current Machinery. Jens Bache-Wüg. (27) Sept. 21.

Reinforced Cement and Concrete Poles for Overhead Electric Lines. Alfred Still. (27) Sept. 28.

The Crank Diagram for Representation of Electrical Power.* Albert A. Nims. (27) Sept. 28.

Farm Electric Lighting by Wind Power.* Putnam A. Bates. (46) Sept. 28.

Tungsten Car Lighting by the Bay State Street Railway.* (17) Sept. 28.

Résistance Electrique des Aciers Spéciaux.* O. Boudouard. (93) Apr.

L'Olisthographe. G.-A. Andrault. (92) July.

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Das neue Fernsprech-Vermittlungsamt in Mainz.* Blohmer. (41) Serial beginning Aug. 22.

Ueber eine neue Metalldampflampe mit weissen Licht.* M. Wolfke. (41) Sept. 5.

Neuere Kabelschutzhüllen und Abdeckungen.* J. Schmidt. (14) Serial beginning Sept. 5.

Ueber einen elektrolytischen Kondensator und seine Anwendung für funkenlosen Kontakt. Karl Siegl. (41) Sept. 5.

Ueber die Verlegung unterseeischer Telegraphenkabel und das deutsche Kabel nach Südamerika. Karl Willy Wagner. (40) Serial beginning Sept. 12.

Ueber den Stand der Sicherungsfrage. Hundhausen. (41) Sept. 12.

Versuche mit der autom. Vakuumschnellbremse auf der elektr. Montreux-Oberland-Bahn.* R. Zehnder Spörry. (107) Sept. 14.

Die Kraftversorgung des Kleingewerbes. E. Vollhardt. (41) Sept. 19.

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Marine Use of Fuel Oil. J. H. Hopps. (55) Vol. 33.

Electrical Equipment for the Propulsion of the U. S. A. Collier *Jupiter.* Eskil Berg. (From *General Electric Review.*) (73) Aug. 30.

The German Motor-Driven Ship *Monte Penedo.* (11) Sept. 6; (12) Aug. 30.

The *Monte Penedo's* Engines.* (12) Sept. 6.

The Imperial German Cruiser *Goeben.** (12) Sept. 6.

Electric-Propulsion Equipment of the U. S. Collier *Jupiter.** (13) Sept. 12.

Paint Tests on the U. S. Receiving Ship *Hancock.** Henry Williams. (13) Sept. 12.

Suction Between Vessels. A. H. Gibson and J. Hannay Thompson. (Paper read before the British Assoc.) (12) Sept. 20.

Marine Propulsion by Electric Transmission.* Henry A. Mavor. (Paper read before the British Assoc.) (26) Sept. 20; (11) Sept. 20; (12) Sept. 20.

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Sulzer Diesel Engined Ship for New York-Rio Service.* J. Rendell Wilson. (95) Oct.
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United States Battleships *Wyoming* and *Arkansas*.* Henderson B. Gregory. (95) Oct.
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Die Einrichtung des neuen Schwimmdocks der Oesterreichisch-ungarischen Kriegsmarine.* R. Dub. (48) Serial begnning Aug. 3.

Mechanical.

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The Edison Roll Crushers.* W. H. Mason. (55) Vol. 33.
Power and Heat Distribution in Cement Mills. L. L. Griffiths. (55) Vol. 33.
Discussion on Cement Manufacture. (55) Vol. 33.
The Assembly of Small Interchangeable Parts.* John Calder. (55) Vol. 33.
The Process of Assembling a Small and Intricate Machine.* Halcolm Ellis. (55) Vol. 33.
Milling Cutters and Their Efficiency.* A. L. De Leeuw. (55) Vol. 33.
Tests of a Sand-Blasting Machine.* Wm. T. Magruder. (55) Vol. 33.
Die Castings.* Amasa Trowbridge. (55) Vol. 33.
Variable-Speed Power Transmission.* George H. Barrus and Chas. M. Manly. (55) Vol. 33.
Oil Engines.* H. R. Setz. (55) Vol. 33.
Test of an 85-H. P. Oil Engine. Forrest M. Towl. (55) Vol. 33.
Design Constants for Small Gasolene Engines.* William D. Ennis. (55) Vol. 33.
Economy of 1 000 K. W. Natural Gas Engine, Tests, Construction and Working Costs.* Edwin D. Dreyfus and V. J. Hultquist. (55) Vol. 33.
Some Experiences with the Pitot Tube on High and Low Air Velocities.* Frank H. Kneeland. (55) Vol. 33.
Producer Gas from Crude Oil. E. C. Jones. (55) Vol. 33.
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The Economic Importance of the Farm Tractor. L. W. Ellis. (55) Vol. 33.
The Purchase of Coal. Dwight T. Randall. (55) Vol. 33.
Energy and Pressure Drop in Compound Steam Turbines.* Forrest E. Cardullo. (55) Vol. 33.
The Pressure-Temperature Relations of Saturated Steam.* Lionel S. Marks. (55) Vol. 33.
Pressure-Recording Indicator for Punching Machinery.* Gardner C. Anthony. (55) Vol. 33.
Tests of Large Boilers at the Detroit Edison Company.* D. S. Jacobus. (55) Vol. 33.
Strain Measurements of Some Steam Boilers Under Hydrostatic Pressure.* James E. Howard. (55) Vol. 33.
Herringbone Gears. Percy C. Day. (55) Vol. 33.
The Dust Problem in Portland Cement Plants and Its Solution. Otto Schott. (55) Vol. 33.
Electrical Power in Cement Plants. Frederick H. Lewis. (55) Vol. 33.
The Core Room: Its Equipment and Management.* Henry M. Lane. (55) Vol. 33.
Furnace Arrangement for Fuel Oil. C. R. Weymouth. (55) Vol. 33.
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Commercial Application of the Turbine Turbo-Compressor.* Richard H. Rice. (55) Vol. 33.
Power Forging, with Special Reference to Steam Hydraulic Forging Presses.* Barthold Gerdau and George Mesta. (55) Vol. 33.
The Influence of Heat on Hardened Tool Steels, with Special Reference to the Heat Generated in Cutting Operations.* Edward G. Herbert. (71) Vol. 85.
Note on the Welding Up of Blowholes and Cavities in Steel Ingots.* J. E. Stead. (71) Vol. 85.
Steam Engines for Driving Reversing Rolling-Mills.* John W. Hall. (71) Vol. 85.
Modern Rock-Crushing Machinery.* John S. Franklin. (10) Aug.
Welding as a Caulking Process.* James Steelman. (10) Aug.
Superheating.* C. R. D. Meier. (98) Aug.
The Strength of Rotating Discs.* (11) Aug. 30.
Formulæ Connecting the Pressure and Temperature of Saturated Steam. S. Godbeer. (11) Aug. 30.

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Coking Practice in the South Wales District.* R. H. Greaves. (Paper read before the British Foundrymen's Assoc.) (47) Aug. 30.

Steam Boiler Efficiency. Edward A. Vehling. (Abstract of paper read before the Am. Master Mechanics' Assoc.) (47) Aug. 30.

Details of 30-Ton Electrically Operated Traverser with Revolving Table.* (11) Aug. 30.

Superheating—Its Economy and the Design of Superheaters to Secure Adjustment and Control of Steam Temperature.* (94) Sept.

A New Method of Testing Boilers.* A. L. Haas. (94) Sept.

The Technique of Gas Manufacture. Alfred E. Forstall. (3) Sept.

Electricity in the Portland Cement Industry. F. C. E. Burnett. (42) Sept.

The Plant of the Crescent Portland Cement Company.* W. B. Ruggles. (67) Sept.

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Notes on Producer Gas Power.* H. F. Smith. (4) Sept.

Some Studies of Welds. E. F. Law, W. H. Merriott, and W. P. Digby. (From *The Locomotive.*) (108) Sept.

Hydraulic Pipe Bending Machines.* A. L. Monrad. (108) Sept.

Cost Questions and the Motor Truck.* R. W. Hutchinson, Jr. (76) Sept. 1.

The Storage, Deterioration, and Spontaneous Combustion of Coal.* Almea. (66) Sept. 3.

A Comparison of Efficiencies and Costs of Steam, Water, Gas and Oil Power Generation.* Seth A. Moulton. (From Report, Maine State Water Storage Comm.) (86) Sept. 4.

A Shoveling Machine for Loading and Handling Loose Material.* (13) Sept. 5.

Combustion of Nitrogen in Coke-Oven Gas.* (11) Sept. 6.

12 000 I. H. P. Vertical Rolling Mill Engines.* (12) Sept. 6.

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Producer Gas Investigations. R. H. Fernald and C. H. Smith. (From *Bulletin* No. 13, U. S. Bureau of Mines.) (47) Sept. 6; (10) Aug.

Experience with Lignite in Texas Central Stations. (27) Sept. 7.

Power Plant for a Large Industrial Establishment.* Charles F. Bowen. (14) Sept. 7.

Automatic Street Lighting and Extinguishing.* George Keillor. (Paper read before the North British Assoc.) (66) Sept. 10.

Gas-Governors: Their Action and Application.* W. Carmichael Peebles. (Paper read before the North British Assoc.) (66) Sept. 10.

Carbonization.* Harold G. Colman. (Paper read before the North British Assoc.) (66) Sept. 10.

The Physical and Chemical Properties of Portland Cement. W. C. Reibling and F. D. Reyes. (Paper read before the Inter. Congress for Applied Chemistry.) (105) Sept. 12.

The Control of Dust in Portland Cement Manufacture by the Cottrell Precipitation Processes. Walter A. Schmidt. (Paper read before the Inter. Congress for Applied Chemistry.) (105) Sept. 12.

The Edison Giant Crushing Roll, Details of an Installation at the National Limestone Company's Plant.* J. F. Springer. (20) Sept. 12.

Note on the Gas-Turbine. Dugald Clark, M. Inst. C. E. (Paper read before the British Assoc.) (11) Sept. 13; (12) Sept. 20; (26) Sept. 20; (47) Sept. 20; (66) Sept. 17; (73) Sept. 13.

Manufacture of Seamless Steel Boiler Tubes.* J. Jay Dunn. (47) Sept. 13.

Oil Engines for Marine and Land Purposes. C. Lakin-Smith, M. Inst. E. E. (Paper read before the Olympia Oil Industries Exhibition.) (47) Sept. 13.

The Flying Boat and Its Possibilities.* Carl Dienstbach. (46) Sept. 14.

The Gnome Rotary Engine.* Earle L. Ovington. (46) Sept. 14.

Measurement of Natural Gas with Pitot Tubes.* C. Oliphant. (Paper read before the Natural Gas Assoc.) (83) Sept. 16.

Some Phases of Present-Day Gas Lighting. C. H. Wiggers. (Paper read before the Wisconsin Gas Assoc.) (24) Sept. 16.

Maintaining Service During Extreme Cold (Gas). D. E. Callender. (Paper read before the Wisconsin Gas Assoc.) (24) Sept. 16.

Manufacture of Balloon Gas from Natural Gas.* F. F. Schauer. (Paper read before the Natural Gas Assoc.) (83) Sept. 16.

Depreciation of Natural Gas Properties. V. A. Hays. (Paper read before the Natural Gas Assoc.) (83) Sept. 16.

Efficiency of Gas Compressors.* P. F. Walker. (Paper read before the Natural Gas Assoc.) (83) Sept. 16.

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Economies in Foundry Mixing and Melting.* Stuart Dean. (20) Serial beginning Sept. 19.

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Design and Construction of Smokestacks.* Henry V. Feder. (From *Building Progress.*) (96) Sept. 19.
The Distribution of Pressure on Inclined Aero-Curves.* A. P. Thurston. (Paper read before the British Assoc.) (11) Sept. 20.
Gain in Power Obtained by Using Jet Condenser with a Simple Engine. Guy L. Andrews. (Paper read before the Stationary Engrs.) (62) Sept. 23.
Limitations of Reducing Wheels.* Julian C. Smallwood. (64) Sept. 24.
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Increasing Steam Boiler Efficiency.* George H. Gibson. (20) Sept. 26.
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Treating Tool Steel by Electricity. C. A. Shaffer. (Abstract of paper read before the Railway Tool Foremen's Assoc.) (62) Sept. 30.
By-Products in Gas Manufacture.* Charles E. Munroe. (Paper read at the Centenary Celebration.) (83) Oct. 1.
High Pressure Gas Lighting. F. W. Goodenough, Oscar Klatte and R. N. Zeek. (Paper read before the Illuminating Eng. Soc.) (83) Oct. 1.
The Electrical Separation of Tar from Coal Gas.* Alfred H. White. (Paper read before the Michigan Gas Assoc.) (83) Oct. 1.
Steam Power Plant Piping Materials. Wm. F. Fischer. (64) Oct. 1.
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Les Applications Electriques de la Métallisation Système Schoop.* F. Loppe. (93) Apr.
L'Allumage Electrique des Moteurs à Explosions et ses Récents Progrès. R. Arnoux. (32) June.
Observations sur la Communication de M. Rateau. G. Eiffel. (32) June.
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Technique Moderne de l'Industrie du Gaz.* R. Masse. (92) July.
Nouvelle Bombe Calorimétrique.* Ch. Féry. (92) July.
Les Nouvelles Recherches Expérimentales sur la Résistance de l'Air et l'Aviation faites aux Laboratoires du Champs de Mars et d'Auteuil.* G. Eiffel. (32) July.
Appareil et Expériences d'Aérodynamique de 1909.* A. Rateau. (32) July.
Les Méthodes Expérimentales Concernant les Voilures et les Hélices Aériennes.* Rodolphe Soreau. (32) July.
Examen de la Méthode de M. J.-Paul Clayton pour l'Etude Expérimentale de la Machine à Vapeur à Piston. V. Dwelshauvers-Dery. (37) Aug. 31.
Phénomènes de Résonance dans la Conduite d'Aspiration des Compresseurs et des Moteurs à Gaz.* P. Voissel. (37) Aug. 31.
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La Fabrication de Gaz Pauvre par Distillation Pyrogénée des Boues de Fosses Septiques. Lucien Cavil. (33) Sept .21.
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Die Kesselbekohlanlage der Zeche Zollern II der Gelsenkirchener Bergwerks-A.-G. A. Pietrkowski. (48) July 20.
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Ueber rotierende Luftpumpen und rotierende Kondensatoren.* Emil Gutmann. (53) Serial beginning Sept. 6.
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Notes on the Solubility of Cementite in Hardenite.* John Oliver Arnold and Leslie Aitchison. (71) Vol. 85.
Improvements in Electric Furnaces and Their Application in the Manufacture of Steel. Hans Nathusius. (71) Vol. 85.
Manufacture and Treatment of Steel for Guns.* L. Cubillo. (71) Vol. 85.
Steels Made in the Electric Furnace.* E. F. Lake. (10) Aug.
Experiments in the Reduction of Iron Ore at Herrang in Sweden.* G. Grondal. (From *Jernkontoret Annaler.*) (22) Aug. 30.
The Production of Black Nickel. (From the *Brass World.*) (47) Sept. 6.
Electric Smelting of Iron Ore. E. F. Burchard. (103) Sept. 7.
Malleable Casting Practice. Richard Moldenke. (Paper read before the Inter. Assoc. for Testing Materials.) (20) Sept. 12.
Making Copper-Clad Steel Products.* (20) Sept. 12.
Reduction of Iron Ores in the Electric Furnace. D. A. Lyon. (Paper read before the Inter. Congress for Applied Chemistry.) (105) Sept. 12.
Notes on Bag Filtration Plants.* Anton Eilers. (Paper read before the Inter. Congress for Applied Chemistry.) (105) Sept. 12.
The Development of the Reverberatory Furnace for Smelting Copper Ores. E. P. Mathewson. (Paper read before the Inter. Congress of Applied Chemistry.) (105) Sept. 12.
The Sulphatizing Roasting of Copper Ores and Concentrates. Utley Wedge. (Paper read before the Inter. Congress for Applied Chemistry.) (105) Sept. 12.
Heat Losses in Electric Furnaces. F. A. J. FitzGerald. (Paper read before the Inter. Congress for Applied Chemistry.) (105) Sept. 12.
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Récentes Recherches sur les Laitons, un Nouveau Point Critique des Alliages Cuivre-Zinc son Interprétation et son Influence sur les Propriétés.* H. C. Carpenter et C. A. Edwards. (93) Apr.
La Production de la Fonte au Four Electrique en Suède, Compte-Rendu des Expériences de Trollhättan.* Paul Nicou. (93) Apr.
Expériences sur la Desaimantation des Aciers au Chauffage.* Fèlix Robin. (32) June.
La Galvanoplastie du Nickel sous de Grandes Epaisseurs. M. A. Hollard. (92) July.
Principes du Grillage de la Blende.* W. Hommel. (93) Sept.
Das Gefüge des gehärteten Stahls.* H. Hanemann. (50) Serial beginning Aug. 22.
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Die chemische Technologie des rauchschwachen Pulvers mit besonderer Berücksichtigung der modernen Jagdpulver. Richard Schnayder. (53) Sept. 20.

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The Production of Petroleum on the Pacific Coast. Arthur F. L. Bell. (55) Vol. 33.
Comparative Evaporative Values of Coal and Oil. C. F. Wieland. (55) Vol. 33.
The Relative Value of Light Oil as Compared with Fuel Oil. Joseph Nisbet Le Conte. (55) Vol. 33.
Safety-Devices in Connexion with Electrical Machinery and Apparatus for Coal-Mines.* David Bowen and Walter E. French, Assoc. M. Inst C. E. (106) Vol. 43, Pt. 5.
A Rope-Driven Coal-Cutter.* Wilfrid L. Spence, Assoc. M. Inst. C. E. (106) Vol. 43, Pt. 5.
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A New Sulphur Operation in the South.* Richard H. Vail. (16) Sept. 7.
Costs at the Erie Mine. S. H. Brockunier. (16) Sept. 7.
Testing of Miners' Safety Lamps. (Report of the Departmental Committee.) (57) Sept. 13; (20) Sept. 13.
The Coalmining Industry in the Hokkaido. H. Wrenacre. (Abstract from Report to the Board of Trade.) (57) Sept. 13.
Churn Drilling in New Mexico.* I. J. Stauber. (16) Sept. 14.
Gold-Dredging in the Boise Basin of Idaho.* John H. Miles. (103) Sept. 14.
Crushing Plant and Sampling Mill of Reinforced Concrete.* K. E. Voorhes. (14) Sept. 14.
Clay Mining Problem a Serious One.* Ellis Lovejoy. (76) Sept. 15.
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Concrete Timbering for Mine Shafts.* E. R. Jones. (13) Sept. 19.
Electric Winding Engines: A Comparison of Systems and the Influence of Drum Profile on the Performance Obtained.* A. E. du Pasquier. (Paper read before the South Wales Inst. of Engrs.) (22) Sept. 20; (57) Sept. 20.
Further Notes on the Analyses of Mine Air Conducted at the Lewis Merthyr Consolidated Collieries.* J. W. Hutchinson and Edgar G. Evans. (Paper read before the South Wales Inst. of Engrs.) (57) Sept. 20; (22) Sept. 20.
The Besshi Mine and Shisaka Smelter.* H. Foster Bain. (103) Sept. 21.
Mining Problems at Santa Gertrudis.* W. G. Matteson. (16) Sept. 21.
Detonator Troubles and Investigations on the Panama Canal. Arthur L. Robinson. (Abstract of paper read before the Inter. Cong. of Applied Chemistry.) (14) Sept. 21.
The Technical Problems of Coal Preparation. W. S. Ayres. (Paper read before the Inter. Cong. of Applied Chemistry.) (19) Sept. 28.
Surface Improvements at Ajax Mine.* S. A. Worcester. (16) Sept. 28.
Generating Energy at Coal Mines.* (27) Sept. 28.

Miscellaneous.

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The Turret Equatorial Telescope; A New Astronomical Observatory.* James Hartness. (55) Vol. 33.
Specifications. Fred S. Sells. (77) July.
La Thermométrie et la Pyrométrie Industrielles.* Eugène Grandmougin. (33) Serial beginning Sept. 7.

Municipal.

Some Notes on Road Maintenance in County Armagh. R. H. Dorman, M. Inst. C. E. (Paper read before the Inst. of Municipal and County Engrs.) (104) Aug. 30.
Scottish Roads. Allan Stevenson. (Paper read before the Inst. of Municipal and County Engrs.) (104) Aug. 30.
Practical Road Building.* John N. Edy, Jun. Am. Soc. C. E. (60) Sept.
Minor Problems of Tarred Roads. Francis G. Wickware. (60) Sept.
Methods of Road Construction and the Problem of Dust Suppression.* Frank B. Earl. (Paper read before the Am. Soc. of Eng. Contractors.) (96) Sept. 5.
Methods of Testing Roadmaking Materials in European Countries. A Mesnager. (Paper read before the Inter. Assoc. for Testing Materials.) (86) Sept. 11.
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Recent Field Work of the Massachusetts Highway Commission.* (14) Sept. 28.

Road Treatment with Asphalt Binder and Sand. (14) Sept. 28.

Essai d'un Nouveau Mode de Compression des Rechargements Généraux d'Empierrements.* Van Volsom. (30) Aug.

Nouveau Système Economique de Rechargement des Chaussées Empierrées. A. Sallé. (35) Sept.

Der Elbtunnel in Hamburg und sein Bau.* O. Stockhausen. (48) Serial beginning Aug. 17.

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Report of Committee 4 of the Am. Ry. Eng. Assoc. on Rails. (85) Vol. 12, Pt. 1; Vol. 12, Pt. 2, and Vol. 13.

Drop Test of Rails, Deflection, Elongation and Compression of 85 Lb., Am. Soc. C. E., Open Hearth Rails in Drop Test.* C. S. Churchill. (85) Vol. 12, Pt. 2.

Carbon and Deflection of Rails in Drop Test.* M. H. Wickhorst. (85) Vol. 12, Pt. 2.

A Study of Forty Failed Rails.* W. C. Cushing. (85) Vol. 12, Pt. 2.

A Study of Sixty-Eight Failed Rails.* W. C. Cushing. (85) Vol. 12, Pt. 2.

Tests and Conclusions.* (On Rails). M. H. Wickhorst. (85) Vol. 12, Pt. 2.

Ductility Tests of Rails under Specifications of the New York Central Lines.* P. H. Dudley. (85) Vol. 12, Pt. 2.

Water Stations for Track Pans.* (Report of Committee, Am. Ry. Eng. Assoc.) (85) Vol. 12, Pt. 3.

Description of One Pipe Circulation Method Track Pans as Installed by the Lake Shore and Michigan Southern Ry. Co., at Painesville, Ohio.* H. H. Ross. (85) Vol. 12, Pt. 3.

Report of Committee 17 of the Am. Ry. Eng. Assoc. on Wood Preservation.* (85) Vol. 12, Pt. 3.

Note on the Strength of Ties Treated with Crude Oil. W. K. Hatt. (85) Vol. 12, Pt. 3.

The Electrical Resistance of Timber as Affected by Treatment with Preservatives. J. T. Butterfield. (85) Vol. 12, Pt. 3.

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Rail Failure Statistics for One Year Ending Oct. 31, 1910 and 1909.* (Report of Committee on Rails, Am. Ry. Eng. Assoc.) (85) Vol. 13 and Vol. 12, Pt. 2.

Comparative Wear of Bessemer Open-Hearth and Nickel Steel Rails on Pennsylvania Railroad. (Report of Committee on Rails, Am. Ry. Eng. Assoc.) (85) Vol. 13.

Segration and Other Rail Properties as Influenced by Size of Ingot.* M. H. Wickhorst. (85) Vol. 13.

Tests of Rail Steel Ingots and Derivative Shapes Made at Watertown Arsenal.* M. H. Wickhorst. (85) Vol. 13.

Specifications for Carbon Steel Rails. (Report of Committee, Am. Ry. Eng. Assoc.) (85) Vol. 13.

A Study of Seventeen Good Service Rails.* Robert Trimble and W. C. Cushing. (85) Vol. 13.

Equated Tonnage Rating for Locomotives.* M. H. Wickhorst. (Paper read before the Am. Ry. Eng. Assoc.) (85) Vol. 13.

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Gravel Washing Plant of the Richmond, Fredericksburg, Potomac and Washington Southern Railways.* S. B. Rice. (85) Vol. 13.
Depth of Stone Ballast.* (Report of General Manager's Committee, Pennsylvania R. R. Co., read before the Am. Ry. Eng. Assoc.) (85) Vol. 13.
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The History, Development and Use of Rails by Railroad Companies of the United States from 1830 to date. P. H. Dudley. (Paper read before the Am. Ry. Eng. Assoc.) (85) Vol. 13.
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Handling Long Trains with Modern Air Brake Equipment. (Paper read by Committee of the Traveling Engrs. Assoc.) (15) Sept. 6; (25) Sept.
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Rational Psychrometric Formulæ, Their Relation to the Problems of Meteorology and of Air Conditioning.* Willis H. Carrier. (55) Vol. 33.
Air-Conditioning Apparatus, Principles Governing Its Application and Operation. Willis H. Carrier and Frank L. Busey. (55) Vol. 33.
The Physics of Air in Relation to Ventilation. A. Saxon Snell. (Paper read before the Royal Sanitary Inst. Congress.) (104) Serial beginning Aug. 30.
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Sewage Treatment at Mt. Vernon, N. Y.* Charles A. Hammond. (13) Sept. 19.
A Complete Sewage Disposal Plant for a Public Institution.* T. Lowes and T. Aird Murray. (Paper read before the Canadian Public Health Assoc.) (96) Sept. 19.
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Wood Preserving Creosotes: Methods of Production, Properties, Quality, Price and Quantity Consumed in the United States. C. P. Winslow. (From *Circular*, U. S. Forest Service.) (86) Sept. 25.
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AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

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TUFA CEMENT, AS MANUFACTURED AND USED ON THE LOS ANGELES AQUEDUCT.

By J. B. Lippincott, M. Am. Soc. C. E.

To be Presented December 4th, 1912.

Los Angeles is situated in a region where the annual rainfall is only 15 in., and where a water supply is requisite, not only for domestic necessities, but also for the beautification of grounds and all forms of intensive agriculture. The Federal census shows that the population of the city increased from 102 479 in 1900 to 319 198 in 1910, or 211%, which is the greatest growth in any of the larger cities of the United States during this period.

General Description of the Line.—The city relies on the Los Angeles River for its local water supply. This stream rises from the gravel beds of the San Fernando Valley, and is uniform in its flow. It has been completely diverted, and encroachments have begun on the underground waters of the neighborhood. What is known as a miner's inch in Southern California is equivalent to 13 000 gal. per day, or $\frac{1}{50}$ cu. ft. per sec. The right to a miner's inch of water of continuous flow in this locality varies in value from $1 000 to $2 000, and is a measure of the scarcity of local water supplies.

Instead of exercising its right of eminent domain, and attempting to condemn other streams in Southern California, which would result in the depletion of commercially tributary areas, the Board of Water

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

Commissioners adopted the broad policy of going to some distant source for its new supply, where the minimum damage would be done to others, and where the maximum quantity of water would be obtained. As the value of water is increasing very rapidly throughout California, it was decided to construct as large an aqueduct as the city could afford. It was found that the most available supply could be obtained from the Owens River, which, for a distance of 120 miles, drains the eastern face of the Sierra Nevada. There are 40 peaks in this crest, the elevation of which rises above 13 000 ft., Mt. Whitney being the culmination of the range, with an elevation of 14 500 ft. This is the source of the water supply. To the east are the Inyo Mountains, a lower range, blanketed by the high Sierra intervening between the Inyos and the Pacific Ocean, and barren of water crop.

Owens River discharges into Owens Lake, having an area of 64 000 acres, from which the annual evaporation loss is about 6.8 ft. The lake has no outlet and consequently is saline. The aqueduct is being built to deliver a continuous flow of 20 000 miners' inches, or 400 cu. ft. per sec., which is two-thirds of the evaporation loss from the lake. The diversion is made 35 miles above the lake, and the city has purchased 105 000 acres of land in Owens Valley, including both banks of the river from the diversion point to the lake.

The precipitation on the crest of the Sierra Range varies from 40 to 60 in., and is mostly in the form of snow occurring during the winter, the drifts accumulating in the high mountain gorges and melting with the approach of summer. These snowbanks, however, are of such extent that they last over from year to year and some of them have compacted into banks of ice. The high-water period occurs in June and July, low water extending from September through the fall and winter. The annual rainfall in the valley floor is only 5 in.

For the first 60 miles, the capacity of the aqueduct as designed is equal to the mean June flood of the river at the intake, or 900 cu. ft. per sec. This portion of the conduit discharges into the Haiwee Reservoir, which has a capacity of 63 000 acre-ft., with a maximum center height of dam of 91 ft. This Haiwee Reservoir will act as a regulator, from which a continuous flow of 420 cu. ft. per sec. will be drawn. In addition to the surface streams, a large Artesian basin has been discovered in Owens Valley, from which ground-waters can be extensively drawn during years of drouth. In case this supply is insufficient, in the driest years and when the consumption of water approaches the full capacity of the aqueduct, the city can build the Long Valley Reservoir, which site it controls. This will have a capacity of 341 000 acre-ft., with a dam having a maximum height of 160 ft.

For the first 20 miles in Owens Valley the conduit is a dredged earthen canal. This part of the line is in the moist bottom lands of Owens Valley, which are saturated with water, and where the aqueduct will gain water. All other portions of the aqueduct are being lined with concrete. The 40 miles of the aqueduct immediately north of the Haiwee Reservoir, because of its large size, is an uncovered, but lined, canal. With the exception of the first 60 miles previously described, all portions of the aqueduct are lined and covered.

From the diversion point in Owens Valley, the line skirts the eastern base of the Sierra Nevada as far south as the Town of Mojave. It then crosses the western edge of the Mojave Desert, passes under the Coast Range, in a tunnel 26 860 ft. long, and then has three drops aggregating 1 842 ft., where power plants are being installed. Immediately above and below the first two power sites, with drops of 1 516 ft., reservoirs are being constructed.

The capacity of the aqueduct between these two power sites has been increased to 1 000 cu. ft. per sec., in order to provide for the variable power load. With these two reservoirs, it will be possible to increase the flow through the power plants during certain hours of the day to 1 000 cu. ft. per sec., and to regulate it back, below the power plants, to a continuous flow of 400 cu. ft. per sec. In other words, the power factor is taken at 40 per cent. Other large storage reservoirs are being built at the extreme southern end of the line.

The total quantity of cement required for the construction of the aqueduct is estimated at 1 500 000 bbl. Table 1 is a summary of the different classifications of work.

The conduit will deliver water at a point 25 miles north of the city, where the distribution system starts. On March 1st, 1912, 83% of the work was finished, and it is being completed within the estimated time and well within the estimated cost.

TABLE 1.—LENGTHS AND SECTIONS OF VARIOUS PORTIONS OF THE LOS ANGELES AQUEDUCT.

Classification.	Length, in miles.	Capacity, in second-feet.
Unlined canal	21	900
Open, lined canal	40	900
Haiwee by-pass	2	420
Covered conduit	98	420
Lined tunnels	43	420
Concrete flumes	0.2	420
Concrete pipe, 10 ft. diameter	2.8	420
Steel pipe	9.4	420
Power tunnels	8.8	1 000
Reservoirs	8.5	.....
Total length	233.7	.....

City Cement Plant.—The city has built a standard Portland cement plant on the Southern Pacific Railroad, near the center of the aqueduct line, at a place named Monolith, which is the brand name given to the cement. The mill has a capacity of 1 200 bbl. per day. The operation of the mill is successful, and the cost of producing the cement is reasonably low.

There are six other Portland cement works in California, the products of which are reliable and satisfactory. Apparently, however, there is a definite agreement among these manufacturers as to the selling price. It was not contended that the city could manufacture cement either cheaper or better than some of these larger plants; but the location of the city's cement plant on the line of the aqueduct eliminates 25 or 30 cents per bbl. in freight charges, and it was believed that the city could manufacture its cement on the line of the work at a price which probably would be lower than that for which manufacturers would sell their delivered product. Moreover, by having its own mill, the city is assured of deliveries at the rate required.

The Monolith cement mill is 14 miles from Mojave. A railroad has been built under contract with the city by the Southern Pacific Company, 140 miles long, northward from Mojave, along the line of the aqueduct; because of this special contract, however, freight rates on this new line are high, and amount to nearly 1 cent per barrel-mile.

Three tufa cement-grinding plants have been established on the line of the aqueduct, namely, Haiwee, Fairmont, and Monolith, extensive deposits existing at each of these points. Haiwee, where the northern tufa-grinding plant has been built, is 120 miles by rail from Monolith, and 106 miles north from Mojave. The southern tufa-grinding plant, at Fairmont, is about 20 miles from the railroad and southwest from Mojave. Transportation charges from Monolith to both Haiwee and Fairmont amount to 90 cents per bbl. As the tufa cement process converts 1 bbl. of standard cement into 2 bbl. of tufa cement, there is saved in transportation charges alone about 45 cents per bbl. on the tufa cement product.

Tuff or tufa is a volcanic, pumiceous rock composed of minute particles bearing indications of having been laid down in water and partly consolidated. Sometimes tufa is a calcareous deposit, but that used for the manufacture of the cement described herein is of volcanic origin. It is of a grayish or creamy color and has a low specific gravity when in rock form; when pulverized, the powder has a specific gravity of 2.2.

According to Dana's "Manual of Geology," puzzuolana is a light-colored tufa found near Rome and elsewhere in Italy, and is used for making hydraulic cement. Puzzuolana is a local name, and tufa or tuff is the geological term. Samples obtained from Italy through the Consular Service in Rome show the puzzuolana to be a light purple-colored fragmental material having somewhat the appearance of volcanic ashes, and unconsolidated. Its analysis is given in Table 2. The tufa used on the Los Angeles aqueduct resembles the German trass, used in the manufacture of the German trass cements.

TABLE 2.—ANALYSIS RECORD OF VARIOUS TUFAS.

No.	Description.	Date made, 1912.	SiO_2.	R_2O_3.*	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	SO_3.	Loss.	Total.
220	Monolith tufa cement..........	1/15	35.34	11.89	......	......	41.05	3.04	......	8.52	
229	Fairmont tufa, middle of quarry	1/29	71.36	16.15	......	......	2.86	trace	0.116	3.22	
230	Fairmont tufa, south side of quarry..........	1/29	70.06	17.11	......	......	1.81	"	0.035	6.51	
233	Monolith tufa......	2/5	68.26	17.10	......	......	2.60	......	......	......	Alkalies.
215	" "	....	69.46	13.89	2.52	11.37	1.80	2.95	0.429	6.28	4.7
...	Hawaiian lava.....	1/15	51.98	18.75	2.90	15.86	9.57	5.61	......	.....	
262	Italian tufa........	3/25	42.36	28.35	......	......	9.15	0.54	0.56	13.68	
263	" puzzuolana	3/25	45.68	30.09	......	......	11.95	3.76	0.56	6.30	

* $R_2O_3 = Fe_2O_3 + Al_2O_3$.

All the tufa along the aqueduct occurs in beds 100 ft. or more in thickness, and shows distinct lines of stratification, indicating that it was laid down in water. The beds near Haiwee are in the immediate neighborhood of ancient volcanoes and lava flows. Ancient craters exist in the desert between Fairmont and Monolith. The Fairmont tufa is the purest of the three deposits. It is fine-grained or comminuted, and portions of the bed are entirely free from pebbles or other foreign matter. The Haiwee tufa is quite free from pebbles, but it contains some mica, which makes the grinding slower. The tufa rock at Monolith is more compact, and has a specific gravity of 1.97. It contains a good many pebbles of a flinty character, and occasionally granitic, which makes the grinding slower, but does not affect the quality of the product. The three tufas used on the aqueduct, when blended with cement, are much the same in strength, the average monthly tests showing greater strength first at one mill and then at another.

Silica cement is a term applied to mixtures of cement and silica, usually in the form of sand, ground together in a dry state to a greater fineness than the Portland cement. This mixture is then used with sand and gravel, as in the ordinary method of preparing concrete. The proportion of pure cement is reduced without a corresponding reduction in the strength of the concrete. The voids in the sand are filled with the ground sand, the gradation of the concrete aggregates being thus carried one step farther. This silica is not soluble with lime, and the cement is improved by the regrinding. In 1899 the United States Geological Survey made investigations of sand cement along the upper portion of the Gila River, in Arizona. The tests were made by laboratory grinds and are shown in Table 3. The silica used was a rock known as pearlite, which is a form of rhyolite, from the Butte dam site, and also a quartzite from the San Carlos dam site.

All the tests were made with the same sample of cement. The mixtures were made by weight. It will be noted in Table 3 that, in the case of the silica cements Nos. 1 and 2, all the cement used was passed through a 200-mesh screen. This was unfortunate, because it gave an abnormal fineness, and consequently an undue strength is shown; but, in the case of Nos. 5 and 6, the straight cement was treated in a similar manner, so that comparisons are possible. The sands used were standard in size, but were not standard testing sands.

Comparisons of Test No. 3 with Test No. 5 show the effect of fine grinding on standard cements.

TABLE 3.—RESULTS OF TESTS OF PORTLAND SAND CEMENT.

No.	Material.	Sand.	Portland cement to sand.	PERCENTAGE OF FINENESS.			Percentage of water.	STRENGTH, IN POUNDS.	
				50 mesh.	100 mesh.	200 mesh.		7 days.	28 days.
1	Colton and Butte Pearlite, 1 to 1.....	2	1 to 5	0.00	0.00	0.00	10	80	300
2	Colton and San Carlos Quartzite, 1 to 1........	2	1 to 5	0.00	0.00	0.00	10	90	345
3	Colton regular.......	2	1 to 2	0.42	7.20	33.20	10	170	385
4	Colton regular.......	3	1 to 3	0.42	7.20	33.20	10	140	240
5	Colton fine ground..	2	1 to 2	0.00	0.00	*	12	370	465
6	Colton fine ground..	3	1 to 3	0.00	0.00	*	12	170	260
7	Colton and Butte Pearlite, 1 to 1.....	3	1 to 7	0.00	0.00	0.00	10	75	155
8	Colton and San Carlos Quartzite, 1 to 1.................	3	1 to 7	0.00	0.00	0.00	10	55	185

* Some left on 200-mesh screen.

Since 1903 the writer, from time to time, has investigated the possibility of blending tufas with cement. He identified the Haiwee deposit of tufa, and shipped some of it to the laboratory at the Monolith cement mill. This led to the identification of the ledge of tufa in the immediate neighborhood of the mill and also to the discovery of the Fairmont deposit. The tufa was first ground with cement experimentally in the laboratory, and showed satisfactory tests. The experiment of mixing the ground tufa with slacked lime, without any cement, was also tried, and it was found that this would set under water and slowly become hard, but it checked in drying in the pats. This hydraulic property indicated the solubility of the tufa in hydrated lime and its power to combine with the excess lime in the cement. This does not occur with silica cement.

A mill run was then made at Monolith, and a length of several hundred feet of canal was lined with tufa cement concrete, in order to observe its working conditions in the field. As this proved satisfactory, it was decided to build tufa regrinding mills at both Fairmont and Haiwee.

The Fairmont mill consists of a Climax jaw crusher which breaks the tufa to about a 1½-in. size. It is then carried to a No. 8 Krupp ball mill, where it is ground to pass through a 20-mesh screen or finer. This ground tufa is then blended in equal parts by volume with the standard cement. This blend is then conveyed to a Gates tube mill, 6 by 16 ft. in size, and the tufa and cement are ground together to a fineness of 90% or more, passing through a 200-mesh sieve. The cost of the plant was $27 000. The grinding is much freer during the dry summer months in California than during the wet winter weather. A little moisture in the tufa seriously reduces the product, as it coats the pebbles, thus lowering their grinding efficiency. At the Fairmont mill it was found that, under natural conditions, from 1 200 to 1 500 sacks of tufa cement could be ground per 24 hours. By arranging crude drying devices and driving off the moisture in the tufa with a slow wood fire, this output was increased to from 1 800 to 2 000 sacks per day. In both the Haiwee and Fairmont quarries, the capacity of the ball mill is 40% in excess of the capacity of the tube mill.

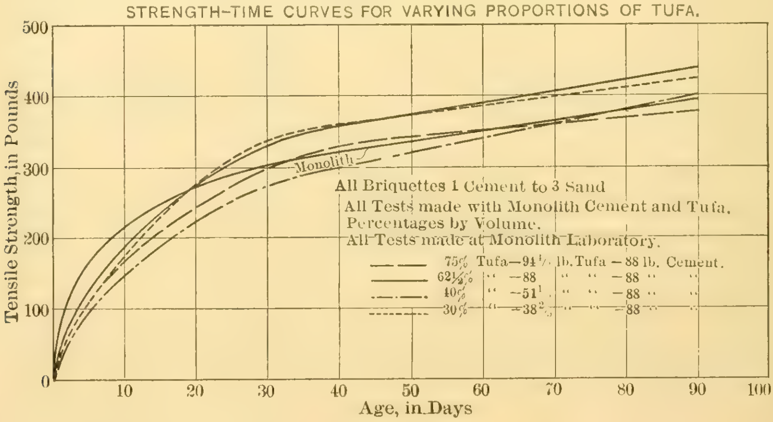

Fig. 1.

Table 2 shows the analysis of various tufas, including the Italian samples and Hawaiian lavas. Tests were made in the laboratory by mixing 4 lb. of tufa, 4 lb. of cement, and 1 lb. of slacked lime. This gave a result from 50 to 75 lb. per sq. in. stronger than when only tufa and cement were used. Subsequently, some mill runs were made with lime added in this manner, but they did not confirm the laboratory tests with lime, and the practice of adding the latter has not been continued. Mill runs were made with varying proportions of tufa at the Fairmont plant, and the results, with different percentages of tufa, are given in Fig. 1. These tests are not fully sustained by later mill and laboratory tests, in that the higher percentages of tufa at first shown were relatively too strong. Possibly the mill run was not long enough to establish thoroughly the various ratios in the output. Finely ground Monolith tufa mixed with thoroughly hydrated lime in the ratio of 75% of lime to 25% of tufa was made into briquettes with sand in the ratio of 3 to 1. The briquettes were left in a damp closet for 28 days and then immersed in water, and gave the following strengths:

7 days.	28 days.	3 months.	6 months.
40 lb.	80 lb.	70 lb.	225 lb.

The briquettes were softened on the surface by the action of the water.

TABLE 4.—TYPICAL SAND BRIQUETTE TESTS, AT MONOLITH, CAL.

Briquette number.	Date made.	Percentage of water.	TENSILE STRENGTH.						Brand.	Percentage of tufa.	FINENESS.		SETTING TIME.				Boiling test, 6 hours.
			3 days.	7 days.	28 days.	3 months.	6 months.	1 year.			100 M.	200 M.	Initial.		Final.		
													H.	M.	H.	M.	
20 Tests	1910 Nov.	9	114	203	408	460	518	577	Tufa Monolith Fairmont	50	98	89	2	19	5	49	O. K.
20 Tests	Dec.	9½	104	160	363	460	477	511	Tufa Monolith Haiwee	52	98	91	3	00	6	12	O. K.

Table 4 shows typical tests of the regular mill runs of the tufa cements, as manufactured at Fairmont and Haiwee, and as used in the construction of the aqueduct. A feature to note is the constant growth in strength of the samples. They are occasionally below the standard of strength required by the American Society for Testing Materials for 7 days (from 150 to 200 lb.), but are above the standard for 28 days (from 200 to 300 lb.). As far as tested, the tufa cements manufactured on the aqueduct uniformly show this growth in strength with age, and in this respect are superior to the tests for strength in straight cement, which often show a loss after 28 days. Tests made by the Santa Fé Railway indicate that this loss in strength of straight cement continues, as far as observed, through a 5-year period, in four out of five brands tested.*

As tufa cements are high in silica, and as the silicates of lime are the more enduring but slower portion in the cements, this growing strength in tufa cement is quite rational. Straight cements which are slow in hardening show the greatest ultimate strengths, and a high 7-day test is regarded with suspicion.

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* *Engineering News*, March 14th, 1912.

Briquettes made of pure tufa cement without sand do not show as great strength as neat cement, but as cement is not used in practice in this form, it is relatively unimportant. The leaner the mixture in sand briquettes, the greater the superiority of the tufa cements is shown to be. Broadly speaking, sand briquettes containing 50% of tufa cement show marked superiority in ultimate strength over straight cement sand briquettes.

TABLE 5.—TUFA SAND BRIQUETTE TESTS, WITH VARYING PROPORTIONS OF TUFA.

Briquette number.	Date made.	Percentage of water.	TENSILE STRENGTH.					Brand.	Percentage of tufa.	FINENESS.		SETTING TIME.				Boiling test, 6 hours.
			3 days.	7 days.	28 days.	3 months.	6 months.			100 M.	200 M.	Initial.		Final.		
												H.	M.	H.	M.	
21	1911 Nov. 28	9½	85 90	200 210	335 345	370 370	330 395	Monolith cement. Monolith tufa.	55	....	91	2	00	4	20	O. K.
22	Dec. 11	9½	30 35	100 100	300 310	460 435	390 385	"	60	....	92	2	10	5	00	"
23	11	9½	35 35	90 100	250 260	350 355	330 365	"	70	....	90	2	00	4	00	"
24	11	9½	15 25	75 80	210 200	300 285	325 375	"	75	....	90	2	10	5	10	"
25	11	9½	15 20	75 80	150 160	255 235	300 305	"	80	....	90	2	50	5	00	"
26	11	9½	15 20	70 70	90 90	140 110	230 260	"	85	....	90	3	00	6	10	"

Table 5 shows a series of tufa cement laboratory tests with varying proportions of Monolith tufa with Monolith cement. This table is not in harmony with the mill-run tests shown in Fig. 1, but it appears to be the more rational. It will be noted that there is far less difference in the strengths at the end of 3 months than at the end of 7 days. Unfortunately, the results of the 1-year tests are not yet available.

Table 6 shows the tests of a mill run of 75% Haiwee tufa. It will be noted that the 6-month tests show a fine increase in strength over the 28-day tests.

TABLE 6.—SAND BRIQUETTE TESTS OF 75% MONOLITH-HAIWEE TUFA.

Briquette number.	Date made.	Percentage of water.	TENSILE STRENGTH.				Brand.	Percentage of tufa.	FINENESS.		SETTING TIME.				Boiling test. 6 hours.
			3 days.	7 days.	28 days.	3 months.			100 M.	200 M.	Initial.		Final.		
											H.	M.	H.	M.	
15 Tests	1911 Nov.	....	52.8	86	201.6	365	Monolith Haiwee tufa	75	99	91	2	00	5	35	O. K.

Fig. 2 shows graphically the average of all breaks of three tufa cements manufactured by the City of Los Angeles during September, 1911. The standard Monolith cement is blended with 50% of tufa by volume. This is the standard practice on the aqueduct work. In making the test briquettes, the straight cement and tufa cement are mixed with standard sand in the ratio of 3 to 1 by weight, except in the one case shown, where the mix is 3 to 1 by volume. The tufa cement weighs 83 lb. per cu. ft., and the straight cement 95 lb. Standard sand weighs 110 lb. per cu. ft. A mixture by weight, as compared with volume, between tufa cement and straight cement, therefore, gives the former an advantage of 14% in the quantity of cement used. However, in mixing the tufa cement with sand by volume, and straight cement with sand by weight, and making the comparison, this is reversed, as the sand weighs 16% more than straight cement. In making concrete the field practice is to mix by volume, which, in the briquette, gives an idea of the strengths obtained in field practice with the tufa cements. Fig. 2 shows that the tufa cements are slower in getting their strength, usually attaining equal strength with the standard cement in from 6 to 10 days, but continuing to grow in strength, as far as observed, as shown in Fig. 3. All tests made in the aqueduct laboratories indicate this continued growth in strength of tufa cements. The standard cement, however, shows a loss in strength between 1 and 4 months, and then a slow recovery. Other California cement tested in the aqueduct laboratories shows similar loss.

In addition to the laboratory tests of the strength of the tufa, the sands and gravels which are used along the line of the aqueduct, were made into concrete with the tufa cements, and cast into test slabs, 6 ft. wide and 12 ft. 5½ in. long, and loaded to destruction. These slabs were similar to those used in covering the aqueduct. Table 7 shows the details of these tests. The slabs were reinforced as indicated, and in a manner similar to the reinforcement used in the construction of the aqueduct. The wire mesh used is manufactured by the American Steel and Wire Company, being from 58 to 42 in. wide. The practice was to roll these bundles longitudinally along the roof of the aqueduct. The mesh is triangular, 4 in. on a side, with No. 12 longitudinal and No. 14 diagonal wires. The concrete was made by hand, covered with a layer of earth and kept wet for 20 days, after

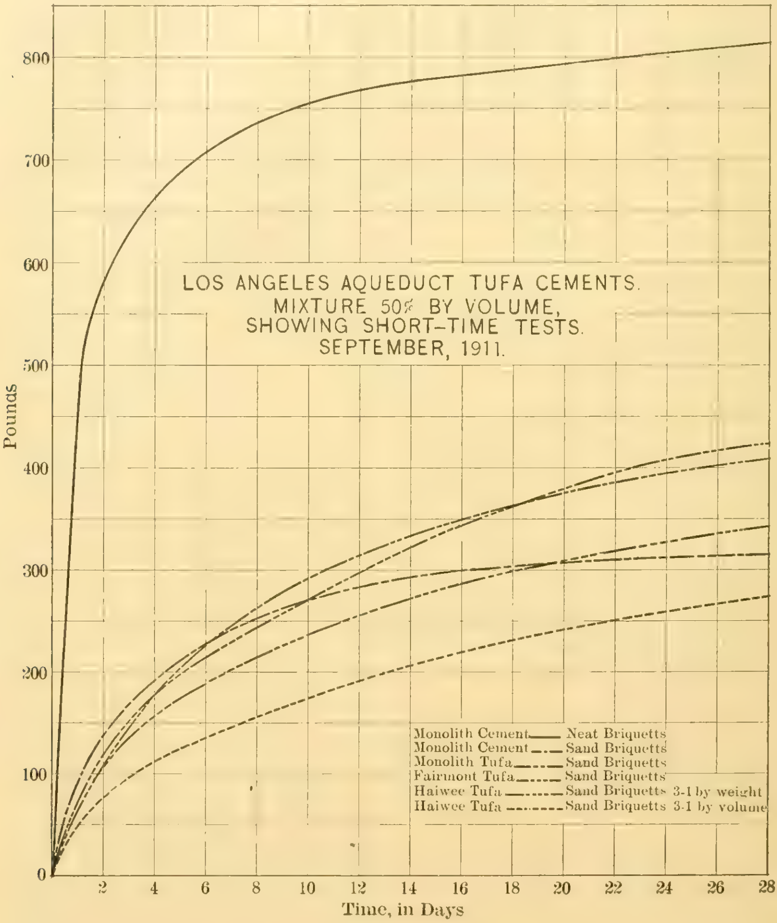
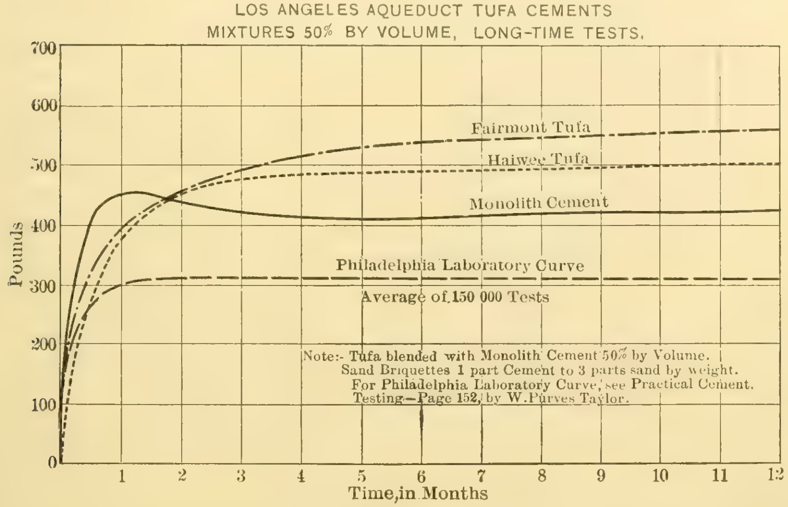


FIG. 2.

which the slabs were dried until they were tested. The slabs were put over piers with a clear span of 11 ft. 5⅝ in. A water load was used, a large canvas bag being put inside of a wooden frame. Tests were first made with earth loads, but the arching effect of the earth destroyed their value. Tufa cements of varying proportions were used, and, in these field tests, the 50% blend gave the most satisfactory results. The tufa cement concretes were stronger than the others. The tests with the straight cement slabs, unfortunately, were made with the reinforcing rods running straight across the bottom of the slab, instead of being bent up at the two sides, as was the case with the tufa cement slabs. In no case were the rods broken in the tests.



LOS ANGELES AQUEDUCT TUFA CEMENTS
MIXTURES 50% BY VOLUME, LONG-TIME TESTS.

Note:- Tufa blended with Monolith Cement 50% by Volume.
Sand Briquettes 1 part Cement to 3 parts sand by weight.
For Philadelphia Laboratory Curve, see Practical Cement. Testing—Page 152, by W. Purves Taylor.

FIG. 3.

The tufa concrete had greater flexibility than the straight cement concrete. After having made this series of tests, the tufa cement was adopted for all classes of construction work on the aqueduct, including the concrete pipe. Five concrete pipes, 10 ft. in diameter, and having a 9-in. shell, reinforced with circular rods 4 in. apart, have now been made of tufa cement, the mixtures being 1 : 2 : 4. These pipes have been made for heads up to 75 ft. They have all been filled with water but one, which is necessarily empty until certain other connecting work is completed. Where they have been tested, the pipes are tight, with one exception where a slight circular crack developed. When this pipe was filled with water and soaked up, the crack closed

TABLE 7.—TESTS OF CONCRETE SLABS MADE OF TUFA CEMENT.

Slab no.	Kind of cement.	Proportions of mix.	Date made.	Age.	Description. Dimensions of slabs. Reinforcement: kind, size, how placed.	Manner of loading.	Depth of equivalent earth load at 100 lb. per cu. ft.	Total loads.	Deflections.	Remarks.
3	Tufa-Portland, 50% tufa.	1 : 2½ : 5	2/28	30	12 ft. 5½ in. by 6 ft. 0 in. 8 in. thick at center. 6 in. thick at ends. Four ⅝-in. twisted rods, spaced 18 in. center to center: ½ in. from bottom of slab at center: bent to middle at ends. Wire mesh.	Water load	0 ft. 8¼ in.	5 000	$\frac{1}{16}$ in.	Crack at 6 000 lb
							1 " 4½ "	10 000	¼ "	
							2 " 1 "	15 000	½ "	
							2 " 9 "	20 000	$\frac{11}{16}$ "	
							3 " 5½ "	25 000	1 "	
							4 " 1¾ "	30 000	1$\frac{5}{16}$ "	Poor bearing-R. Broke within 8 in. of rear end.
							4 " 4 "	32 225		
4	Tufa-Portland, 40% tufa.	1 : 2½ : 5	2/24	30	Ditto.	Ditto.	0 " 8¼ "	5 000	⅛ "	Crack at 1 000 lb.
							1 " 4½ "	10 000	$\frac{7}{16}$ "	
							2 " 1 "	15 000	$\frac{15}{16}$ "	
							2 " 9 "	20 000	2$\frac{1}{16}$ "	
							2 " 10½ "	21 000		Failure. Broke in center. Slow break.
5	Tufa-Portland, 62½% tufa.	1 : 2½ : 5	3/9	30	Ditto.	Ditto.	0 " 8¼ "	5 000	¼ "	
							1 " 4½ "	10 000	$\frac{7}{16}$ "	
							2 " 1 "	15 000	$\frac{13}{16}$ "	
							2 " 9 "	20 000	1$\frac{5}{16}$ "	
							3 " 4 "	24 000	2$\frac{3}{16}$ "	
							3 " 5½ "	25 000		Broke left end. Slow break.
6	Monolith Portland.......	1 : 2½ : 5	2/10	30	12 ft. 5½ in. by 6 ft. 0 in. 6 in. uniform thickness. Four ⅝-in. square twisted rods, ½ in. from bottom of slab. Straight rods. Wire mesh.	Ditto.	0 " 8¼ "	5 000	$\frac{3}{16}$ "	
							1 " 4½ "	10 000	$\frac{9}{16}$ "	
							2 " 1 "	15 000	1$\frac{7}{16}$ "	Broke 4 ft. from left end. One of the end rods pulled out.
							2 " 3¼ "	16 500		
1	Tufa-Portland, 30% tufa.	1 : 2½ : 5	2/12	31	12 ft. 5½ in. by 6 ft. 0 in. 8 in. thick at center line. 6 in. thick at ends. Four ⅝-in. square twisted rods, spaced 18 in. center to center: ½ in. from bottom of slab at center; bent to middle at ends. Wire mesh.	Ditto.	0 " 8¼ "	5 000	⅛ "	
							1 " 4½ "	10 000	$\frac{5}{16}$ "	Crack at 7 500 lb.
							1 " 8¾ "	12 500	⅝ "	
							2 " 1 "	15 000	¾ "	
								15 050		Failed. Rods taken out.
2	Tufa-Portland, 50% tufa.	1 : 2½ : 5	2/17	....	Ditto.	Ditto.	0 " 8¼ "	5 000	$\frac{1}{16}$ "	Crack in center.
							1 " 4½ "	10 000	$\frac{3}{16}$ "	
							1 " 8¾ "	12 500	¼ "	Crack ¼ pt. to left.
							2 " 1 "	15 000	⅜ "	Crack at 14 000 quarter to right.
							2 " 5 "	17 500	$\frac{7}{16}$ "	
							2 " 9 "	20 000	$\frac{9}{16}$ "	
							3 " 5½ "	25 000	¾ "	
							4 " 1¾ "	30 000	1 "	
							4 " 10 "	35 000	1$\frac{5}{16}$ "	No failure. Test discontinued. Permanent set of 1¾ in. when load taken off.
							5 " 2¼ "	37 500	1½ "	
							5 " 6¾ "	40 000	1⅞ "	
							5 " 10⅝ "	42 500	2$\frac{9}{16}$ "	

and became tight. In no case have any longitudinal cracks developed, and it is believed that the entire water load is carried by the concrete alone. When concrete takes its set, it shrinks slightly and throws the circular reinforcing steel under compression. Before the steel can carry the load, it must come under tension, and experience with concrete pipe elsewhere indicates that there is enough movement between these two conditions of tension and compression of the steel to cause a longitudinal crack in the concrete unless it carries the entire load. As a practical working test, therefore, this pipe of tufa concrete demonstrates the quality of the material.

The tufa concrete has also been used successfully in the lining of some tunnels in which the ground is exceedingly heavy, and where the sets in the tunnel, made of 10 by 10-in. timbers, spaced from 2 to 3 ft. apart, were repeatedly crushed. The tunnel lining, which has a theoretical thickness between posts of 14 in., has not shown any failure. In the heaviest ground, however, 6-in. steel I-beams were placed and wedged up against the lagging, the wooden sets then being taken out. This was done because in some instances the timbers were so close together that they reduced seriously the thickness of the concrete tunnel walls. The steel I-beams are left embedded in the concrete as a reinforcement.

Laboratory tests of the tufa product are made continuously at all the tufa mills, and samples are also sent to the main laboratory at the Monolith cement plant. Figs. 2 and 3 represent an average of a month's breaks of briquettes made with equal parts by volume of straight cement and tufa mixed with three parts of standard sand. These are fairly typical of the average monthly mill runs, the tufa cements showing better results than the straight cements and also showing a continued hardening. In the case of the German trass cements, this hardening is known to continue for a period of five years. The lower line on Fig. 3 shows the average of a great number of breaks of various Portland cements at the Philadelphia Testing Laboratories.

A striking feature of the tufa cement is that, in all the four years in which it has been tested, there has never been a pat which failed under the boiling test. This indicates, further, that any free lime which may occur in the cement combines with the silicas in the tufa. Microscopic slides were made of some of the tufa cement and sand briquettes. They were examined, but no satisfactory conclusion could be reached.

Samples of tufa cement were sent to the Bureau of Standards of the United States Department of Commerce and Labor, and were tested in the Pittsburgh Laboratory. The following quotation is from a letter from this Bureau under date of March 29th, 1911:

"* * * You desired particularly to know whether there was any chemical reaction between the tufa and the cement. The enclosed report shows that such has undoubtedly been the case.

"The addition of tufa or puzzuolana to Portland cement undoubtedly does not reduce the strength of the latter when in the form of a mortar or concrete, but there has always been a question as to whether this is due to purely chemical or chemical and physical phenomena. There has not been any doubt that there is a reaction between the cement and the tufa, but there always has been a doubt as to whether this reaction was sufficient to account for the usual strengths developed by such mixtures.

"The tests were conducted as follows: Mixtures of two parts Riverside cement with one part of tufa, and two parts Riverside cement with one part Ottawa Standard sand, ground 90% through a 200-mesh sieve, were made into briquettes and broken at the end of one-week, four-week, and thirteen-week periods. At the same time, a similar series, using Atlas cement, was carried on, and also the same mixtures used in connection with 1:3 sand briquettes. After breaking the thirteen-week period briquettes, they were dried, the outside surface completely removed, and the interior ground to pass 200 mesh, and used for determinations. By determining the amount of insoluble silica in the cements and in the tufa and quartz, it is possible to calculate the amount of insoluble silica which should be in the dry briquettes (by dry, meaning the complete expulsion of water and CO_2 at 1 000 degrees C). From the analyses of these residues, there was also obtained the insoluble silica actually present. The difference between these two gives the amount of silica rendered soluble during this period of thirteen weeks. The figures are given in the following table:*

"The following results were obtained in breaking the briquettes:

Riverside.	2 Riverside, 1 tufa.	2 Riverside, 1 quartz.	
0.53	30.97	34.02	SiO_2 insoluble, calculated.
0.53	23.80	32.76	SiO_2 insoluble, determined.
	7.17	1.26	SiO_2 rendered soluble.

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* "Tests made at Monolith show 8.4% of Monolith tufa rendered soluble; of the Italian Puzzuolana, 1.6%, and of Italian Tufa, 2 per cent. The presence of this so-called 'soluble silica' is what makes tufas preferable to sands for blending with Portland cements."

Atlas.	2 Atlas, 1 tufa.	2 Atlas, 1 quartz.	
0.59 0.59	30.80 24.01	33.89 33.00	SiO_2 insoluble, calculated. SiO_2 insoluble, determined.
	6.71	0.89	SiO_2 rendered soluble.

TABLE 8.—LOS ANGELES AQUEDUCT TUFA COMPARED WITH SILICA CEMENT.

			1 week.	4 weeks.	13 weeks.
Sand.	Riverside cement	1 2 3	307 303 310	370 383 394	416 413 390
	Average		307	382	403
	2 Riverside cement 1 Tufa, 90% through 200 mesh	1 2 3	215 211 221	373 302 341	458 585 438
	Average		215	339	457
	2 Riverside cement 1 Quartz sand, 90% through 200 mesh	1 2 3	210 190 188	272 286 281	286 286 303
	Average		196	280	292
	Tufa cement, 50% by volume Tufa and Riverside cement	1 2 3	262 269 235	488 476 466	534 561 478
	Average		255	477	524
Sand.	Atlas cement	1 2 3	357 299 281	341 351 335	454 484 469
	Average		312	342	466
	2 Atlas cement 1 Tufa, 90% through 200 mesh	1 2 3	212 212 200	350 398 410	462 471 ...
	Average		208	386	466
	2 Atlas cement 1 Quartz sand, 90% through 200 mesh	1 2 3	205 200 200	265 283 255	314 362 367
	Average		203	268	348

The neat briquettes made with tufa cement by the Bureau do not show as much strength as those made with straight cement. This is in harmony with tests made in the aqueduct laboratories. However, when cement is used in concrete, it is always blended with sand, and the sand briquettes tested correspond to practice in construction work. The tests made with the sand briquettes show that the tufa cements have as good or better strength than the straight cements, and that the blend made of equal parts of tufa and cement is stronger than that made with but 33% of tufa. They also show clearly that the tufa cement, when mixed with sand, gives much better strength than the silica cement, indicating that the tufa combines in a different manner from the silica. In the neat briquettes, however, the silica cements develop the greater strength. The characteristic of the tufa cement continuing to harden substantially with age is indicated in these sand briquette tests. At the time the samples were sent to Pittsburgh, the Fairmont tufa was being blended with Riverside Portland cement. All other tests given of Los Angeles aqueduct tufas were made with the city's cement known as Monolith.

A review of an elaborate series of tests of the German trass cement, is given in a recent engineering periodical.* These are the best available laboratory tests of tufa cements. The investigations were carried on especially to determine the effect of sea water on cements of this class. They were made under the direction of the Prussian Minister of Public Works, and a committee consisting of representatives of the Royal Testing Laboratories, of the cement and trass industries, and Dr. Michaelis, cement specialist. The Royal Testing Laboratories were placed in their charge. Cements of two classes were used, those rich in lime and those poor in lime, and also mortars to which had been added trass and finely ground quartz sand, in order to determine whether trass only acts mechanically by increasing the density of the mortar, or chemically also. The tufas blend slightly better with the cements which are richer in lime. The results of these tests show that the addition of certain puzzuolana (tufa) materials to lean cement mortar is valuable in sea water. The detailed table (Table 9) is given because of the variety in the record, the long period of the tests, and the excellence of the authority. The tests run over a period of five years.*

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* *Engineering Record*, August 27th, 1910.

This cement (Table 9) contained 65.80% of lime, and 23.74% of silica. The cements which have been blended with trass give as much tensile strength as the straight cement when made in sand briquettes, and the samples put in sea water show results of slightly less strength than when they are put in fresh water. The compressive strength of the concrete is less with the trass cements than with the straight cements.

An additional table† shows the strength of mortars and concrete made with a mixture of three parts of trass, two parts of hydrated lime, and one part of sand, giving tensile strengths of 216 lb. in 28 days, 356 lb. in 1 year, and 400 lb. in 5 years. A mixture made of 1½ of trass, 1 of hydrated lime, and 1 of sand gave a strength of 244 lb. in 28 days, 383 lb. in 1 year, and 360 lb. in 5 years.

It is noteworthy in Table 9 that the straight cement sand briquettes, in three out of four instances, show marked loss in tensile strength between 1 and 5 years, the first test alone showing constant strength, while the tufa (trass) combinations show gains in six out of eight cases during the same periods. The two tests showing loss are of samples in sea water.

Dr. W. Michaelis‡ has written an interesting paper on "Portland Cement Reground with Oregon Puzzuolana," in which he enters into a discussion of the chemistry of the problem, and makes a demonstration of the solubility of the tufa with the excess lime of the cement. He shows that puzzuolana (or tufa) will combine with hydrated lime. The series of tests given show the same general results as the tests with German trass cements (Table 9)—that, especially with the leaner mixtures, the tufa blends of equal parts are fully as strong in tension, or superior to, the straight cement mortars, and markedly better than the "silica cement." In the tests for compression in the leaner concretes (1:3:6), his tufas are as strong; but with a richer mixture (1:2:4), they are about 20% less strong than concrete made of straight cement with the same aggregates.

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* The results have appeared in a report of the Royal Testing Laboratory under the title, "Mitteilungen aus dem Kgl. Materialprüfungsamt."

† *Engineering Record*, August 27th, 1910.

‡ *Cement and Engineering News*, November, 1911.

TABLE 9.—TESTS OF GERMAN TRASS CEMENTS IN SEA WATER (IN POUNDS PER SQUARE INCH).

Age of samples.	STORED IN FRESH WATER.						STORED IN SEA WATER.					
	Stored in sand 9 days.			Stored in sand 1 year.			Stored in sand 9 days.			Stored in sand 1 year.		
	Tensile strength.	Compressive strength.		Tensile strength.	Compressive strength.		Tensile strength.	Compressive strength.		Tensile strength.	Compressive strength.	
		Mortar cubes.	Concrete cubes.		Mortar cubes.	Concrete cubes.		Mortar cubes.	Concrete cubes.		Mortar cubes.	Concrete cubes.
1 CEMENT, 2 SAND.												
28 days....	572	6 760	7 040	....	......	......	646	6 790	7 170	....	......	......
1 year....	722	7 740	7 540	710	8 870	7 500	750	7 470	7 400	....	......	......
5 years...	722	6 320	7 590	750	9 530	7 720	612	7 620	7 700	859	11 900	7 820
1 CEMENT, 4 SAND.												
28 days....	348	2 990	3 390	....	......	......	362	2 960	3 520	....	......	......
1 year....	426	3 400	3 640	524	4 890	4 440	457	3 660	3 960	....	......	......
5 years...	362	3 320	4 030	439	3 760	4 340	369	3 440	4 420	442	4 040	4 440
1 CEMENT, 1 TRASS, 4 SAND.												
28 days....	504	3 470	4 290	....	......	......	539	3 030	4 670	....	......	......
1 year....	616	5 860	5 520	622	5 970	5 820	749	5 900	5 340	....	......	......
5 years...	722	6 300	5 570	697	6 040	5 740	583	6 560	5 260	719	6 440	6 070
1½ CEMENT, 1 TRASS, 5 SAND.												
28 days....	573	5 170	4 870	....	......	......	597	5 400	4 890	....	......	......
1 year....	640	7 200	5 670	617	6 970	6 100	672	7 220	6 120	....	......	......
5 years...	724	7 230	6 680	716	6 690	6 090	663	7 570	6 160	744	7 140	6 130
1 CEMENT, 1 TRASS, 8 SAND.												
28 days....	242	1 560	2 120	....	......	......	292	1 700	2 140	....	......	......
1 year....	353	2 420	2 920	404	3 400	3 240	360	2 690	2 820	....	......	......
5 years...	399	2 820	3 230	370	2 370	3 060	394	2 890	3 090	344	2 490	3 120
1½ CEMENT, 1 TRASS, 10 SAND.												
28 days....	240	1 430	2 140	....	......	......	262	1 430	2 220	....	......	......
1 year....	320	2 240	2 790	347	2 840	3 260	324	2 100	2 760	....	......	......
5 years...	329	2 220	3 090	419	3 020	3 330	329	2 240	2 900	437	3 260	3 260

Dr. Michaelis gives the following explanation of the chemical reactions that occur when the tufa combines with the cement:

"These desired hydrates of silica, alumina and iron oxide are found in nature in the form of puzzuolanas, or tufas, volcanic products created by the action of water or steam upon basaltic or granitelike molten formations. They can be artificially obtained by running molten blast furnace slag into water. In both cases the original compounds of the basalt, granite or slag are completely decomposed into their constituents and, furthermore, transformed into comparatively loose material which can easily be crushed. The most valuable part of the various chemical ingredients to be found in a natural or artificial puzzuolana is the silica hydrate, so-called 'soluble' silica which, in distinction from quartz silica, powdered quartz, is soluble in a 10 per cent. solution of sodium carbonate. Such silica combines readily with calcium hydrate and forms an excellent hydraulic cement. To what extent the alumina hydrate and iron hydrate combine with calcium hydrate has not been definitely ascertained. However, from recent researches it appears that especially the alumina hydrate is able to combine with a very large percentage of hydrated lime."

Cost to Manufacture.—The average cost of blending 1 bbl. of straight cement so as to produce 2 bbl. of tufa cement with the small mills installed on the Los Angeles aqueduct is about 74 cents, distributed as follows:

	Cost per barrel of blend.
General expense—labor, live stock, etc.	$0.04
Electric power, at 1.85 cents per kw-hr.	0.105
Quarrying	0.025
Mill operations	0.20
Net milling cost	$0.37

The process of blending 1 bbl. of straight cement with an equal part by volume of tufa gives a resulting product of approximately 10% in volume in excess of 2 bbl. of tufa cement. For this reason, a little more than 1 cu. ft. of tufa cement is put in a sack. A sack of tufa cement weighs 83 lb. The cost of milling tufa cement will vary with the density of the rock. This cost of 37 cents per bbl. of tufa cement applies to all three of the tufa-grinding plants. The tufa at Monolith is denser and slower to grind; but, as this tufa mill is a part of a larger plant, the milling costs are no greater than at the other two places.

Action of Tufa Cement in Field Work.—Tufa cement is more sensitive and requires greater care in curing than straight cement, because it is slower in reaching its final hardness. As a rule, Los Angeles aqueduct tufa cements will show as great strength in 7 days as the straight cements, and after that period the tufa cement gains in strength faster than the straight cement. (See Fig. 2.) The tufa cement has to be kept wet longer in hot weather to attain full strength, and is subject to frost longer in cold weather. In slab work, where it is supported by forms, the forms should be left in two or three days longer with tufa cement than with straight cement. When the aqueduct roof slab (which has a span of 11 ft. 5 in.) is made of tufa cement, the forms are stripped in 6 days, in moderate weather. The particular places for which tufa cement is adapted is in massive work, foundations, and in wet places. It is not claimed that it is suitable for high, thin walls exposed to the dry air of arid regions. It may be, but this has not yet been demonstrated on this work.

Gaugings made in arid America show that the greater portion of irrigation water diverted in earthen canals is lost by seepage before it reaches the fields. A lean tufa cement containing 75% of tufa could be used for earthen canal linings, and would be fully as dense as concrete made with straight cement. It would have sufficient strength to stand up on 1:1 slopes, and it can be given as smooth a surface as ordinary concrete. A length of several hundred feet of open canal lining of this kind has been put in the open flood section of the Los Angeles aqueduct, with 75% tufa. The concrete does not show up as hard in the field as the 50% tufa concrete, but it is satisfactory. Tufa cement, in being more finely ground, adheres somewhat more to the forms than concrete made with straight cement, which is a slight disadvantage. In places along the aqueduct where 50% tufa concrete joins concrete made with straight cement, both being a year old or more, no difference can be detected in the quality of the concrete by picking into it. Plaster made of tufa cement is smoother, and the laborers, after they get used to it, prefer it to straight cement plaster.

Prejudice Against New Cement.—Some cement manufacturers take a stand against tufa cement for two reasons: because it is a cheaper product, with which they would have to compete; and because, having established a business for a standard Portland cement, anything which might be considered an adulteration would possibly mitigate against the reputation of all cements. This active opposition has already been encountered among the cement manufacturers in Southern California, who opposed the proposed building ordinance of Los Angeles containing a provision permitting the use of tufa cements. If, however, a product can be furnished which is cheaper in cost and as good in quality, the consumer should have the benefit of it, and undoubtedly will ultimately derive this benefit.

Some foremen and superintendents are also prejudiced against the use of a new product. This is true generally in various branches of industry, and it applies to tufa cement. On the Los Angeles aqueduct, it was found that some of the foremen at first endeavored to avoid the use of tufa cement, but now, after the lapse of two or three years, and having had some practical experience with it, they are willing to accept either that or straight cement from the city mills without any hesitation for all classes of work.

Other Combinations.—Diatomaceous earths are found at various places along the Pacific Coast. Their analysis is similar to the tufas, which they resemble somewhat in appearance and in physical characteristics. A test made with a diatomaceous earth found near Santa Barbara gave the following results:

	Monolith cement. 1 to 3 sand.	½ Monolith and ½ diatomaceous earth.
3 days	100	210
7 days	200	300
28 days	310	370
3 months	330	620

The briquettes were made as provided for in specifications for testing cements. Only one set of tests was made, and this table is not given as conclusive evidence.

In the Hawaiian Islands, the volcanic rocks prevail. As far as the writer's knowledge of that country extends, there are no lime deposits suitable for the manufacture of cement. The black basaltic lava has been analyzed by the branch of the Department of Agriculture located on the islands, and the following contents determined:

SiO_2	TiO_2	Fe_2O_3	Mn_3O_4	K_2O	Na_2O	CaO	MgO	FeO	Al_2O_3
51.98	1.50	2.90	0.92	0.97	2.70	9.57	5.61	6.84	15.85

It is difficult to grind this lava in the mills. There is another form of volcanic material, locally called red clinker, which resembles somewhat in appearance a cement clinker. Experiments were made in grinding with Santa Cruz cement both the basaltic lava and the red clinker in a local tube mill. The results are given in Table 10. After making the first three tests, 1½% of gypsum was added, which improved the strength of the material. All these tests were made with mixtures of one part of the cement indicated to three parts of standard sand. While the results did not seem to be as satisfactory as those obtained with the Southern California tufas, nevertheless, enough strength was developed to indicate the possibility of blending these lavas with cement in such a way as to result in an economy.

It will be noted that the chemical analysis of the lava quite closely resembles the analysis of tufa, and it is this resemblance of chemical properties which suggested the experiments with the lavas. There is a marked difference in their physical characteristics as compared with the tufas. They have not been comminuted by contact with water as the tufas have, a process which is considered important, if not essential.

Conclusions.—The following conclusions are drawn for tufa or puzzuolana cements:

1st.—The tufa, when finely ground with cement and used in concrete, combines both chemically and mechanically. Blends of 50%, when mixed with sand, give greater tensile strength after 10 days than straight cement mixed with the same proportion of sand. The leaner the mixture, the greater the relative superiority of the tufa cement. In compression, the tufa cement concrete is less strong (20%) in rich mixtures (1:2:4), and as strong in leaner mixtures (1:3:6).

2d.—Tufa cements, in tension, of blends from 30 to 80% show a continued growth in strength with age, as far as tested, up to 5 years, and in this respect are superior to straight cements which usually show declining strengths.

3d.—The tufa concretes must be handled with greater care with reference to both cold and drying, and forms should be left in place about one-third longer. In massive work this feature is negligible.

4th.—From the fact that the tufa cement is more finely ground and, in part, combines mechanically with other aggregates, carrying the gradation of fineness one step farther, it makes a denser and more impervious concrete.

5th.—Where cements are high priced, a substantial economy may be effected if deposits of tufa are available. These conditions occur in portions of Western America. The milling cost of producing the extra barrel of tufa cement in small plants should not exceed 75 cents.

TABLE 10.—SAND BRIQUETTE TESTS MADE WITH HAWAIIAN LAVAS.

Briquette number.	Date made.	Percentage of water.	Tensile Strength.				Brand.	Percentage of tufa.	Fineness.		Setting Time.				Boiling test, 6 hours.
			3 days.	7 days.	28 days.	3 months.			100 M.	200 M.	Initial. H.	Initial. M.	Final. H.	Final. M.	
a	1911 Nov.	10½	145 135	250 260	335 345	435 465	Santa Cruz cement and sand..........	....	93.8	......	2	15	6	30	O. K.
b	"	10½	55 105	165 175	250 245	320 330	Red clinker and sand.	50%	......	91	0	40	1	25	"
c	"	10½	110 75	140 150	185 195	250 275	Lava basalt...........	50%	.....	92	0	40	1	20	"
27	Dec.	10½	35 35	100 110	145 150	....	Red clinker Santa Cruz..............	50%	......	91.4	0	40	1	25	"
28	"	10½	125 130	200 210	325 355	....	Red clinker, 1½% gypsum added...	50%	......	......	2	30	6	00	"
29	"	10½	100 110	200 200	340 350	....	Red clinker, 1½% gypsum added...	50%	......	......	2	30	6	00	"
30	"	10½	125 130	190 200	330 335	....	Red clinker, 1½% gypsum added...	50%	......	.....	2	30	6	00	"
31	"	10½	145 145	190 200	310 325	....	Red clinker. 1½% gypsum added...	50%	......	......	2	30	6	00	"
32	"	10½	120 120	215 230	350 340	....	Red clinker, 1½% gypsum added...	50%	......	......	2	30	6	00	"
33	"	10½	135 140	200 200	320 365	... .	Red clinker, 1½% gypsum added...	50%	......	......	2	30	6	00	"
34	"	10½	120 140	195 200	350 345	....	Red clinker, 1½% gypsum added...	50%	......	......	2	30	6	00	"
35	1912 Jan.	....	145 140	245 255	330 330	....	Red clinker, 1½% gypsum added...	50%	......	......	2	30	6	00	"
36	"	....	130 140	220 225	300 310	....	Red clinker, 1½% gypsum added...	50%	.....	......	2	30	6	00	"
37	"	10½	55 55	120 125	180 190	....	Blue lava.......	50%	......	......	1	00	11	00	"
38	"	10½	80 80	135 150	275 275	....	"	50%	......	......	1	00	11	00	"
39	"	10½	60 65	150 160	240 255	....	"	50%	......	......	1	00	11	00	"

The development of the tufa cement on the aqueduct, as is usually the case with affairs of this kind, is the result of the co-operation of a number of different parties. Mr. E. Duryee, Cement Chemist for the aqueduct at that time, conducted the preliminary experiments. Mr. G. M. Andrews, who succeeded Mr. Duryee as Cement Chemist, has done a great deal in investigating these cements. The cement plant is under the direction of Mr. Roderick MacKay, Mechanical Constructor, and William Mulholland, M. Am. Soc. C. E., is Chief Engineer in general charge of the work on the aqueduct. The writer has been Assistant Chief Engineer since the beginning of the work.

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A SHORTENED METHOD IN ARCH COMPUTATION.*

By H. A. Sewell, Esq.†

In the design of elastic arches, as given by William Cain, M. Am. Soc. C. E., the method of single loads is more accurate than that of resultant moment polygon, because it computes the moment and thrust for each load separately, while the latter computes these quantities for all the loads together. Thus, in computing

$$\Sigma (mb' y) = \frac{\Sigma (bh) \Sigma (y)}{N} - \Sigma (bh' y),$$

the two quantities in the right member of the equality are so nearly equal in the latter method that they must be multiplied out by long hand, hence multiplying errors; while in the former the quantities dealt with are so much smaller that an ordinary slide-rule will usually suffice, thus eliminating false accuracy.

On the other hand the polygon method requires the computation of, at most, only six polygons, corresponding to different positions of the live load; while the method of single loads requires as many polygons as there are loads to the left of the crown, although these latter are somewhat easier to compute.

Because of its greater accuracy, and because it determines the exact position of the live load for maximum moment at any given section, rather than assumes its arbitrary position for maximum moments, the single-load method, doubtless, would be much more widely used,

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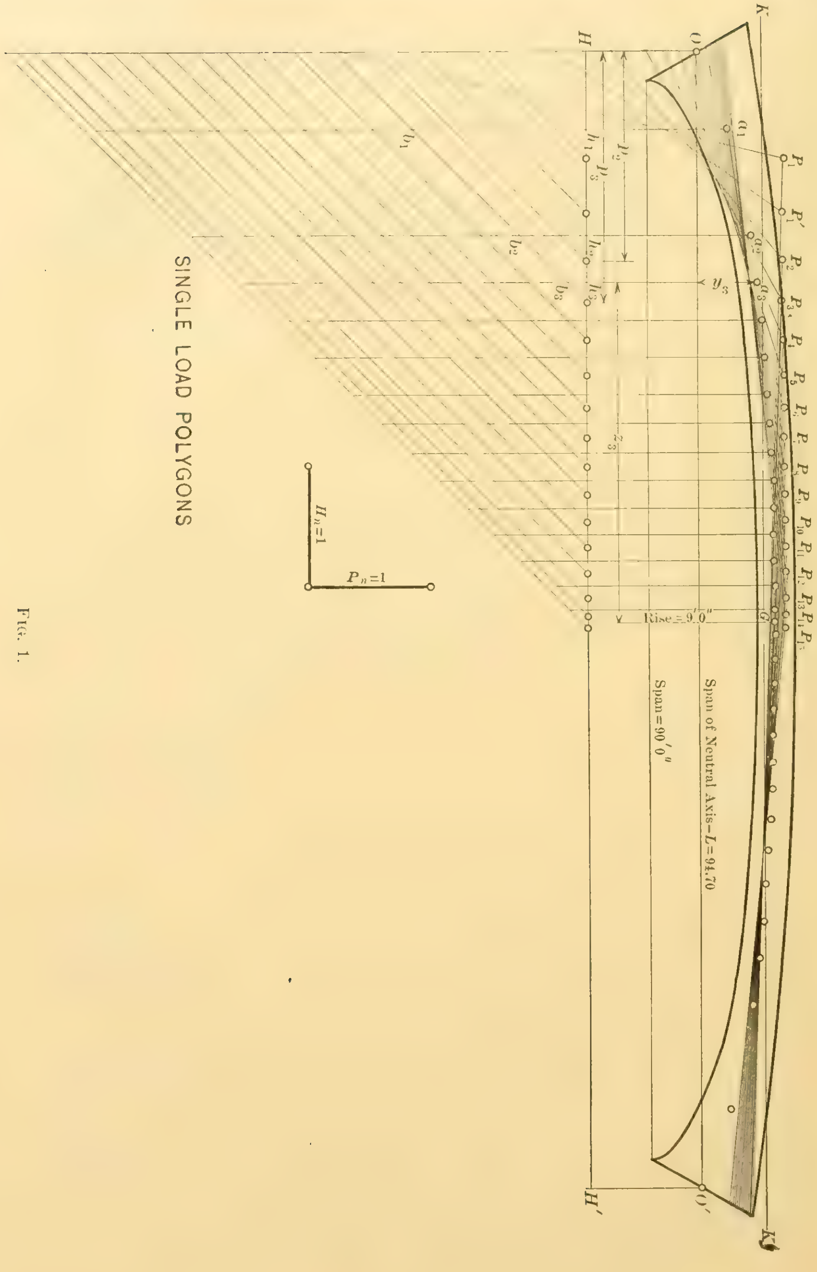
* This paper will not be presented at any meeting, but written communications on the subject are invited for publication with it in *Transactions*.

† Instructor in Elementary Mathematics, State College of Washington.



SINGLE LOAD POLYGONS

FIG. 1.

TABLE 1.

Point	(z)	(y)	(z^2)	(y^2)	Load	P	$\frac{L}{2}-P$	$P_n-P_{(n-1)}$	$\Sigma_o^{n-1}(z)$	$\Sigma_o^{n-1}(y)$	$\Sigma\,(bh)$	$\Sigma(bh'z)$	$\Sigma(bh'y)$
a_1	40.80	2.50	1664.0	6.25	P_1 P_1'	8.90 13.42	38.45 33.93	8.90 4.52			2.35 6.87	96.0 280.5	5.88 17.18
a_2	31.97	4.43	1022.0	19.62	P_2	17.35	30.00	3.93	40.80 31.97	2.50 4.43	3.93 1.97 12.77	160.5 63.0 504.0	9.83 8.73 35.74
a_3	28.13	4.95	791.5	24.50	P_3	20.88	26.47	3.53	72.77 28.13	6.93 4.95	7.06 1.66 21.49	257.0 46.7 807.7	24.46 8.22 68.42
a_4	24.84	5.25	617.0	27.55	P_4	24.04	23.31	3.16	100.90 24.84	11.88 5.25	9.48 1.53 32.50	318.6 38.0 1164.3	37.52 8.03 113.97
a_5	21.82	5.52	496.0	30.50	P_5	26.96	20.39	2.92	125.74 21.82	17.13 5.52	11.68 1.43 45.61	367.0 31.2 1562.5	50.05 7.90 171.92
a_6	19.02	5.75	361.8	33.05	P_6	29.64	17.71	2.68	147.56 19.02	22.65 5.75	13.40 1.31 60.32	395.3 24.9 1982.7	60.70 7.53 240.15
a_7	16.47	5.92	271.2	35.05	P_7	32.13	15.22	2.49	166.58 16.47	28.40 5.92	14.94 1.25 76.51	415.0 20.6 2418.3	70.80 7.41 318.36
a_8	14.00	6.05	196.0	36.60	P_8	34.54	12.81	2.41	183.05 14.00	34.32 6.05	16.87 1.19 94.57	441.5 16.7 2876.5	82.78 7.20 408.34
a_9	11.67	6.16	136.0	37.95	P_9	36.83	10.52	2.29	197.05 11.67	40.37 6.16	18.32 1.15 114.04	451.3 13.3 3341.1	92.45 7.09 507.88
a_{10}	9.42	6.25	88.7	39.10	P_{10}	39.04	8.31	2.21	208.72 9.42	46.53 6.25	19.89 1.11 135.04	461.5 10.5 3813.1	102.95 6.95 617.77
a_{11}	7.25	6.32	52.6	39.95	P_{11}	41.18	6.17	2.14	218.14 7.25	52.78 6.32	21.40 1.08 157.52	467.0 7.8 4287.9	113.00 6.83 737.60
a_{12}	5.14	6.37	26.4	40.60	P_{12}	43.27	4.08	2.09	225.39 5.14	59.10 6.37	22.99 1.06 181.57	471.0 5.4 4764.3	123.50 6.76 867.86
a_{13}	3.06	6.39	9.4	40.80	P_{13}	45.33	2.02	2.06	230.53 3.06	65.47 6.39	24.72 1.04 207.33	475.0 3.2 5242.5	134.80 6.65 1009.31
a_{14}	1.01	6.40	1.0	40.90	P_{14}	46.85	0.50	1.52	233.59 1.01	71.86 6.40	19.76 0.51 227.60	355.2 0.5 5598.2	109.20 3.26 1121.71
Σ_0^{14}	234.60	78.26	5713.6	452.42	P_{15}	47.85	−0.50	1.00	234.60	78.26	14.00 241.60	234.6 5832.8	

especially for very flat or very high arches, were it not for the much greater labor involved. However, in the following method, the computations are greatly reduced, while, at the same time, a check is introduced, which cuts the labor of computing moments again by making the computations self-checking.

The summations, $\Sigma\ (y)$, $\Sigma\ (y^2)$, $\Sigma\ (z)$, and $\Sigma\ (z^2)$, having been computed for the arch ring by the usual method, the quantities, $\Sigma\ (bh)$, $\Sigma\ (bh'\ z)$, and $\Sigma\ (bh'\ y)$, should next be obtained for each of the trial polygons corresponding to loads unity and horizontal thrusts unity at each of the load points, P_n.

The force polygon for load unity and horizontal thrust unity is taken so that the pole point is one unit horizontally to the left of the lower extremity of the load vector unity, thus making the right component of each trial-moment polygon horizontal and the left component inclined downward at an angle of 45 degrees. By reference to Fig. 1, the following relations are discovered:

$$\sum_o^n (bh) = \sum_o^{n-1} (bh) + (n-1)\,(p_n - p_{(n-1)}) + \left(p_n - \frac{L}{2} + z_n\right)$$

$$\sum_o^n (bh'\ z) = \sum_o^{n-1} (bh'\ z) + (p_n - p_{(n-1)}) \sum_o^{n-1} (z) + \left(p_n - \frac{L}{2} + z_n\right) z_n$$

$$\sum_o^n (bh'\ y) = \sum_o^{n-1} (bh'\ y) + (p_n - p_{(n-1)}) \sum_o^{n-1} (y) + \left(p_n - \frac{L}{2} + z_n\right) y_n$$

in which:

L = span of the neutral axis;

y = ordinate at a of arch from horizontal through spring, OO';

z = distance of a to left of crown, G;

p = distance of load considered from left spring, O;

n = number of load considered from left;

bh = ordinate of polygon from horizontal, HH'.

Thus, each summation is made to depend on the one preceding it and the quantities $(p_n - p_{(n-1)})$ and $\left(p_n - \frac{L}{2} + z_n\right)$. The work of these computations on a hypothetical flat arch is shown in Table 1.

In order to make the use of the formulas clear, a case is taken, $P_n = P_3$, from Table 1. Then for $P_{(n-1)} = P_2$, $\Sigma\ (bh) = 12.77$, $\Sigma\ (bh'\ z) = 504.0$, and $\Sigma\ (bh'\ y) = 35.74$; and, by adding the values of $z_{(n-1)} = z_2$, and $y_{(n-1)} = y_2$ to the last totals, we obtain $\sum_{o}^{n-1} (z) = 72.77$ and $\sum_{o}^{n-1} (y) = 6.93$. Multiply these latter quantities by the value of $(p_n - p_{(n-1)}) = 3.53$ and place the products under the values of $\Sigma\ (bh'\ z)$ and $\Sigma\ (bh'\ y)$ given above; and multiply $(p_n - p_{(n-1)})$ by $(n - 1) = 2$, placing the result under $\Sigma\ (bh)$. Next obtain $\left(p_n - \frac{L}{2} - z_n\right) - z_n \left(\frac{L}{2} - p_n\right) = 1.66$, and place it in the $\Sigma\ (bh)$ column; then multiply it by $z_n = 28.13$ and $y_n = 4.95$, placing the results in the $\Sigma\ (bh'\ z)$ and $\Sigma\ (bh'\ y)$ columns. Finally, add the quantities below the last addition, in order to obtain the totals, $\Sigma\ (bh) = 21.49$, $\Sigma\ (bh'\ z) = 807.7$, and $\Sigma\ (bh'\ y) = 68.42$.

The check on the totals is shown by $\Sigma\ (z)$ being equally distant from $\Sigma\ (bh)$ for the loads, P_{14} and P_{15}. Likewise, $\Sigma\ (z^2)$ should be midway between $\Sigma\ (bh'\ z)$ for the loads P_{14} and P_{15}. No check was discovered for $\Sigma\ (bh'\ y)$ except to compute $\Sigma\ (bh'\ y)$ for Point P_{14} independently by the usual method. $\Sigma\ (z)$ and $\Sigma\ (y)$ are checked by direct addition. Checking the totals for P_{14}, checks all the others, because they are all carried forward in making the totals. All the multiplications may be made with an ordinary slide-rule.

These summations being obtained, the work is carried forward in the usual manner as outlined by Professor Cain.

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THE ECONOMIC ASPECT OF SEEPAGE AND OTHER LOSSES IN IRRIGATION SYSTEMS.*

By E. G. Hopson, M. Am. Soc. C. E.

To be Presented December 4th, 1912.

In a report to the Comptroller of New York City, made by John R. Freeman, M. Am. Soc. C. E., in 1900, on the New York water supply, attention was drawn in a very clear and forceful manner to the enormous proportion of waste incident to the operation of a great city water-works system. The subject had been dealt with before by other engineers, and has been handled in a very comprehensive way by others since, but the writer did not recall at the time ever having seen the subject dealt with so comprehensively as in Mr. Freeman's report.

On page 38 of that report there is an interesting diagram showing the consumption of Croton water hour by hour during a typical week. By an ingenious interpretation of related, but more or less disjointed, bits of evidence, it was shown that of a daily delivery of 115 gal. to each inhabitant of the city, only about 40 gal. were really used and about 75 were wasted, that is, the proportion of use to waste was about 1:2.

It was further deduced that of the 75 gal. wasted, 65 was in all probability needless waste, and could be stopped by the adoption of proper measures. Naturally, the question arose as to whether it was worth while for a city to continue to lavish vast sums in the con-

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* Read at the Annual Convention of the Society, Seattle, Wash., June 27th, 1912.

struction of new works, the greater part of the product of which would flow into the sea without benefit to any one, or whether it would not be better policy to devote some of this money to internal improvements in works already built, whereby savings equivalent in their effect to extensions of the supply system could be effected. Since the Freeman report was made much additional information has been gained on waste and its prevention in city water-works systems, and it has been shown that the amount of what was termed by Mr. Freeman needless waste is not quite so great as has been supposed. The question as to whether enforced economy in use is better policy than increasing the capacity of the system is still, to a large extent, a debatable one.

The reasons in favor of moderate consumption and avoidance of waste apply with even greater force to an irrigation system than to a city water-works system, in spite of the fact that the cost of the latter is relatively much higher than that of irrigation works. In a great city the cost of water-works is a comparatively light burden to the community, the expense to the individual of an unrestricted supply of pure water being one of the smallest items in his annual expense account. On the other hand, anything in the nature of restriction in use directly affects the personal convenience of each inhabitant, and is resented; he often prefers paying an extra trifle in order to enjoy not only a sufficiency but an excess.

With an irrigation system conditions are different. Usually, the supply is limited in quantity, and a waste in one direction is immediately reflected by straitened conditions in another. A system of irrigation work is designed to supply a definite quantity of water to each acre of land. The engineer makes certain allowances for waste and losses by seepage and evaporation. If his calculations are correct, the land receives a supply considered by him as sufficient, but not excessive. If, however, through some unexpected cause, the waste or losses are greater than were anticipated, less land can be brought under cultivation than had been contemplated, or farmers are compelled to get along with less water than had been considered necessary; hence the results are felt immediately and directly.

In the case of irrigation, as with a water-works system, losses can be classed as curable and incurable, and it is the writer's purpose to consider briefly those classes, as illustrated by works constructed

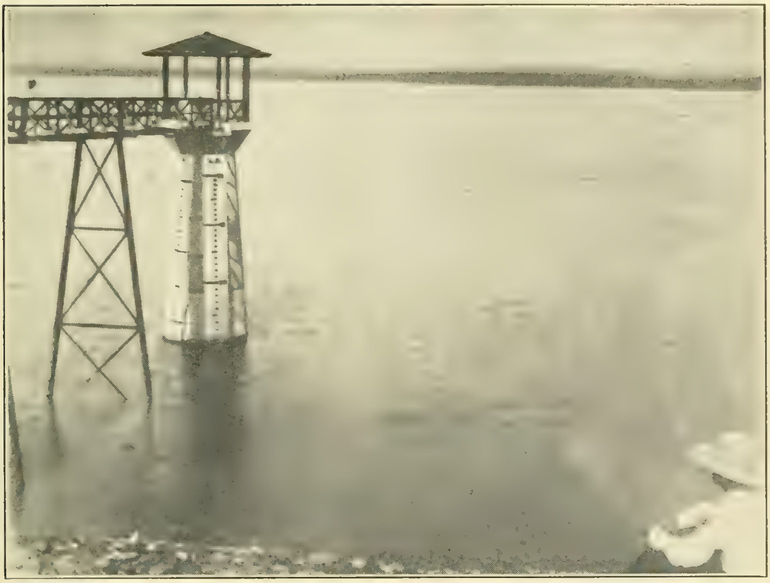


FIG. 1.—COLD SPRINGS RESERVOIR, OREGON.

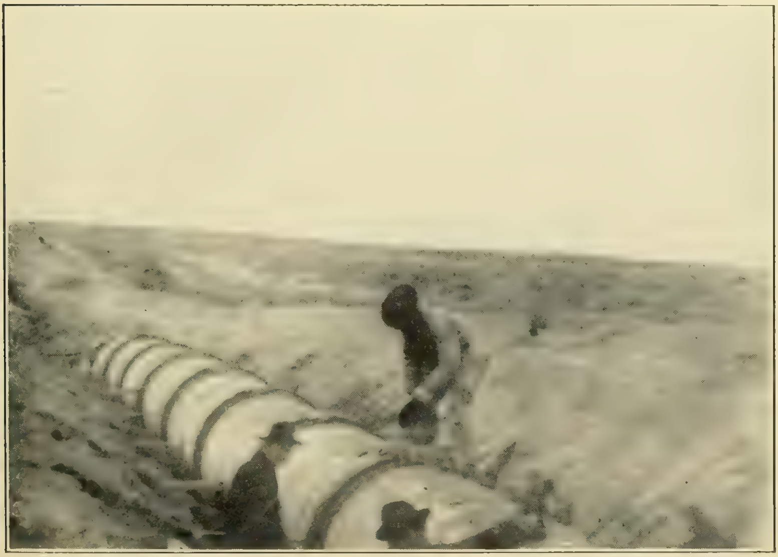


FIG. 2.—JOINTING 46-INCH CONCRETE PIPE, UMATILLA PROJECT.

by the Government in the Northwest during the last five or six years.

Roughly speaking, incurable losses in irrigation systems result directly through water lost by absorption in the beds of reservoirs and evaporated into the air. Curable loss lies almost wholly in that absorbed in the beds of canals and other conduits.

In the great storage reservoirs required for irrigation works it is obviously an economic impossibility to accomplish anything in the way of preventing absorption or seepage losses in their beds. Whatever losses result through this cause must be accepted as unavoidable. The engineer, however, must be prepared to accept responsibility for results, as his advice or decision on the all-important question of selecting or approving a reservoir site is the only safeguard against what may be disastrous loss if his judgment is ill-advised. For this reason the writer is illustrating the fundamental differences in conditions and results in four typical irrigation reservoirs built in the Northwest by the United States Government.

The East Park Reservoir is strictly a storage reservoir, built on a branch of Stony Creek, one of the Coast Range feeders of the Sacramento River. The dam site is a good one, being a notch in a great conglomerate dike or ridge that runs through the country in a north and south direction, and the dam is a solid masonry structure of the gravity type on an arched plan. The bed of the reservoir is practically wholly in the typical California shale. The dam was completed in 1910, and water was first stored in the winter and spring of 1910 and 1911. Weekly measurements are taken of the influent and effluent, the storage, and the rates of evaporation.

The maximum capacity of the reservoir is 45 000 acre-ft., and the maximum area of water surface is 1 690 acres. Table 1 shows the results in the season of 1910-11, the season being from November 1st to November 1st, in this and all the following cases.

TABLE 1.—EAST PARK RESERVOIR, 1910–11.

	Acre-feet.	Percentage of influent.
Influent	65 400	..
Effluent and losses:		
Evaporation	7 100	11
Use, waste and surplus	58 300	89
*Seepage	0	0

* No appreciable seepage loss.

This reservoir represents the highest condition of efficiency of any of the four described. The records fail to show any seepage loss, the only appreciable loss being that by evaporation; thus nearly 90% of the water entering this reservoir is available for use.

The Cold Springs Reservoir of the Umatilla Project, in Oregon, is a good average reservoir, from a Western standpoint. In the East it would probably not be regarded as a site of special promise. The dam is an earthen one, nearly 4 000 ft. long, of a maximum height of nearly 100 ft. The general structure of the country is volcanic, with vast overlying beds of stratified sands, gravels, and hardpan. The valley constituting the reservoir site is the outlet of some 200 sq. miles of drainage area with little or no ordinary run-off. The reservoir is supplied by a feed canal, some 25 miles long, diverting from the Umatilla River at times when the latter has available water. The capacity of the reservoir is 50 000 acre-ft., and its maximum area is 1 550 acres.

This reservoir was first placed in commission in the spring of 1908, and has been operated ever since. There are, therefore, four yearly records of results. In this case measurements were obtained with unusual accuracy, as practically all the inflow passed over a sharp-crested weir at the lower end of the feed canal, and the effluent was also carefully measured over another weir below the outlet gates. This reservoir shows losses ranging from 34 to 24% of the influent during the four-year period. Judging by the record of the past two years, it would appear that a fair condition of stability has been attained in the regimen, in which about one-fourth of the water entering this reservoir is subject to unavoidable loss through seepage and evaporation. Table 2 gives a summarized tabulation of the results.

The Clear Lake Reservoir, in California, situated just south of the California-Oregon line, is a feature of the Klamath Project. It occupies a great natural depression or sink, some 25 000 acres in extent, at the reservoir flow line. About one-half of the bed consists of a natural sink of alkaline water known as Clear Lake which for ages has received and evaporated the surplus waters of Willow Creek. This reservoir was built by the Government principally for the purpose of holding back the waters of Willow Creek, in order to facilitate the unwatering of lands marginal to Tule Lake, a body of water into which Willow Creek ultimately discharges. The reservoir was intended to

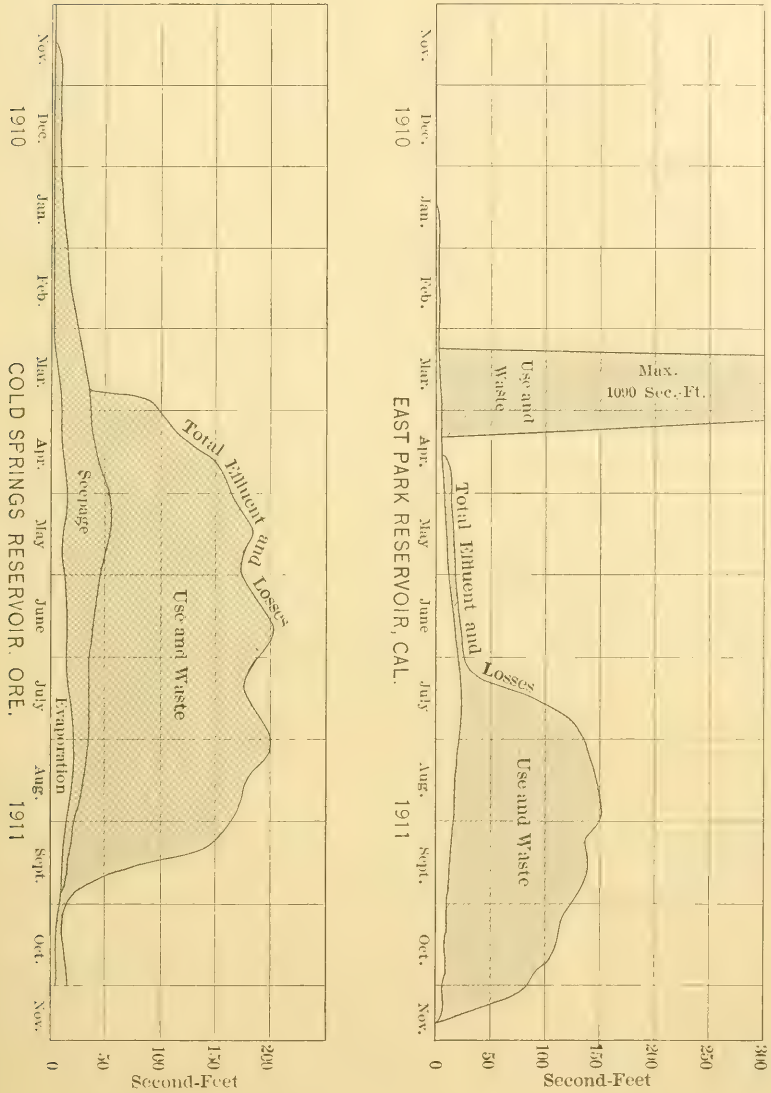

COLD SPRINGS RESERVOIR. ORE.
1910
1911
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Total Effluent and Losses
Seepage
Use and Waste
Evaporation
0
50
100
150
200
Second-Feet
EAST PARK RESERVOIR, CAL.
1910
1911
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Use and Waste
Max. 1090 Sec.-Ft.
Total Effluent and Losses
Use and Waste
0
50
100
150
200
250
300
Second-Feet

FIG. 1.

TABLE 2.—COLD SPRINGS RESERVOIR, OREGON.
Percentage of Losses Expressed in Terms of the Influent.

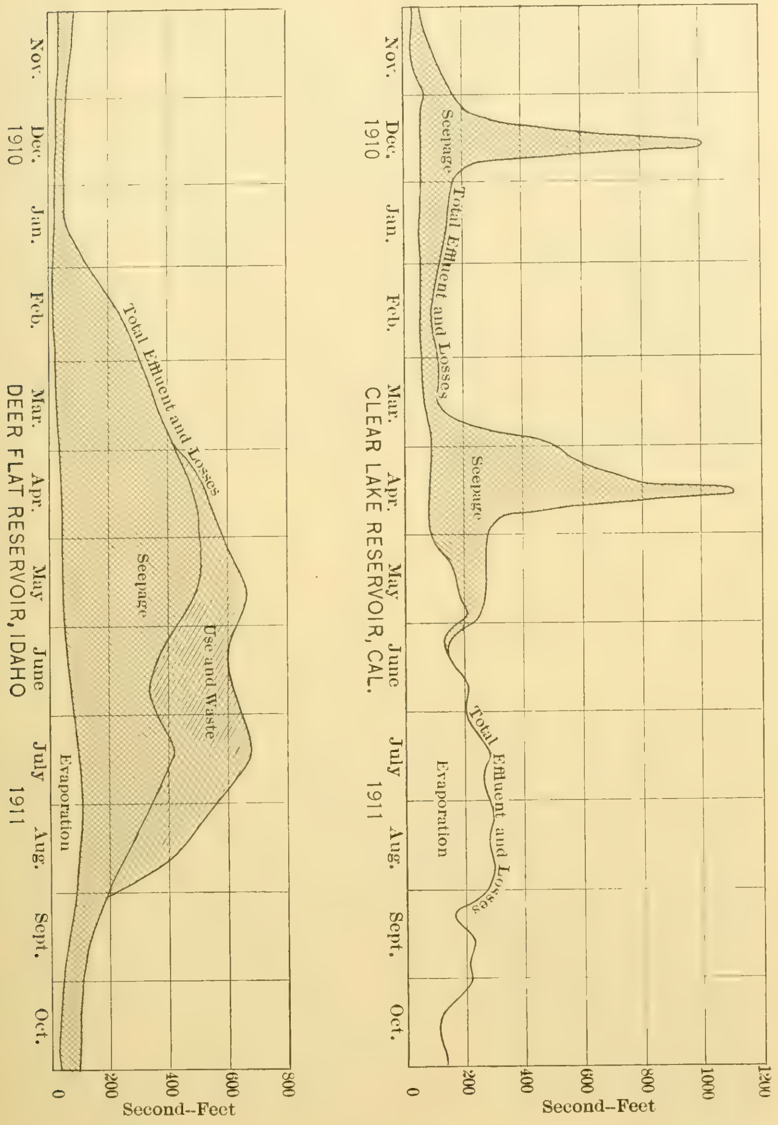
	1908.		1908-09.		1909-10.		1910-11.	
	Acre-feet.	Percentage.	Acre-feet.	Percentage.	Acre-feet.	Percentage.	Acre-feet.	Percentage.
Influent	20 366	..	42 820	..	61 526	..	72 273	..
Effluent and losses :								
Evaporation	2 400	12	4 295	10	5 333	9	6 252	9
Seepage	4 515	22	*4 021	9	*10 461	17	10 878	15
Use, waste, and surplus	13 451	66	34 504	81	45 732	74	55 163	76
*Return flow	......	..	865	..	503	..	182	..

combine the purposes of a great evaporating pan and a regulator of the diversion channel that diverts the discharge of Lost River from Tule Lake into Klamath River. More recent plans, however, have considered its possibilities as a source of irrigation supply. The capacity of the reservoir is enormous as compared with the available water supply, being 450 000 acre-ft., with an area of 25 000 acres. The dam on Willow Creek is a rock fill structure some 30 ft. high, which was completed in 1909. There are two years' records of the action of this reservoir, as given in Table 3.

TABLE 3.—CLEAR LAKE RESERVOIR.

	1909-10.		1910-11.	
	Acre-feet.	Percentage.	Acre-feet.	Percentage.
Influent	141 000	....	225 000	....
Effluent and losses :				
Evaporation	80 000	57	88 000	39
Seepage	48 000	34	24 000	11
Use, waste, and surplus	13 000	9	113 000	50

The rate of evaporation in this vicinity has been estimated at a little more than 4 ft. in an average year. It will be noted that evaporation is the principal loss in the Clear Lake Reservoir, as had been anticipated. The seepage losses during the first year were heavy, but, apparently, the marginal lands have filled up so that the losses in 1911 were comparatively moderate. It is important to note that in a year of copious run-off, like 1910-11, as much as 50% of the



CLEAR LAKE RESERVOIR, CAL.

DEER FLAT RESERVOIR, IDAHO

Fig. 2.

supply was subject to unavoidable loss or waste, which, in this case, was intentional, the principal purpose of the reservoir being the disposition of surplus water, rather than its conservation for use.

The Deer Flat Reservoir, a feature of the Boise Project, in Idaho, presents different natural conditions from the three preceding types. It does not occupy a natural drainage valley or sink, but, on the contrary, is situated on a flat saddle between the hills, the lower ends of which are closed by two earthen dams. It has a maximum area at high-water line of 9 250 acres, with a maximum capacity of 186 000 acre-ft. The reservoir derives its supply, as in the case of the Cold Springs Reservoir, through a feeder canal, known as the New York Canal, diverting from the Boise River some 10 miles southeast of Boise. The reservoir was first placed in commission in 1909, and has been in operation ever since. The bed consists in large part of silts, sands, and gravels, with a covering of from 3 to 5 ft. of soil. Seepage losses in this case have been pronounced from the outset, and constitute the bulk of all losses. When the reservoir was first placed in commission almost 90% of the water entering it was lost by absorption in the reservoir bed. In that year, however, the reservoir was only filled to one-tenth of its capacity. During the next two seasons larger and larger quantities of water were introduced, and the proportion of losses has fallen appreciably, but still remains exceedingly high. During the last season about two-thirds of the water entering this reservoir was subject to loss through evaporation and seepage. It may be expected that conditions will improve at this point as the adjacent and underlying strata of the reservoir gradually become filled by the constant application of water, but the extent and period of these ameliorating conditions are quite uncertain. A summarized tabulation of results is given in Table 4.

TABLE 4.—DEER FLAT RESERVOIR.

	1909.		1909-10.		1910-11.	
	Acre-feet.	Percentage.	Acre-feet.	Percentage.	Acre-feet.	Percentage.
Influent	64 000	......	130 000	......	230 000	.....
Effluent:						
Evaporation	4 000	6	18 000	14	20 000	9
Seepage	55 000	86	80 000	62	140 000	61
Use, waste, and surplus	5 000	8	32 000	24	70 000	30

PLATE XCVIII.
PAPERS, AM. SOC. C. E.
OCTOBER, 1912.
HOPSON ON
SEEPAGE LOSSES IN IRRIGATION SYSTEMS.

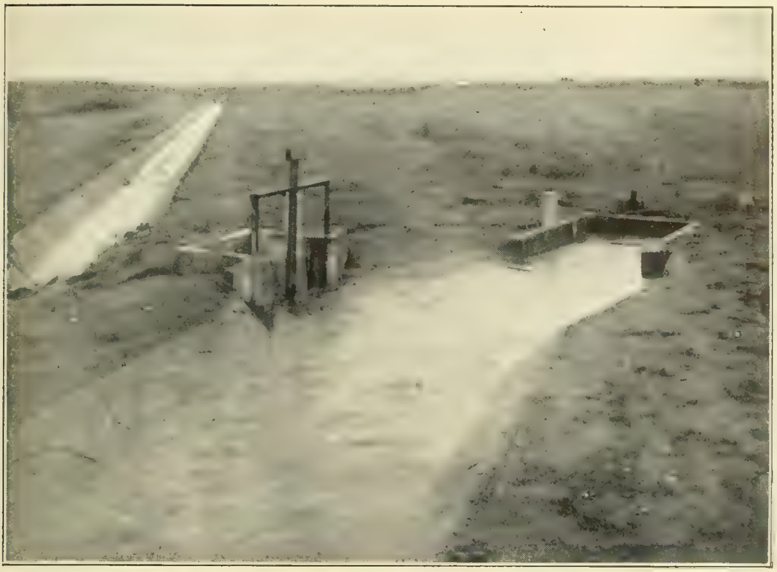


FIG. 1.—MORTAR-LINED LATERALS AND CONCRETE STRUCTURES, UMATILLA PROJECT.

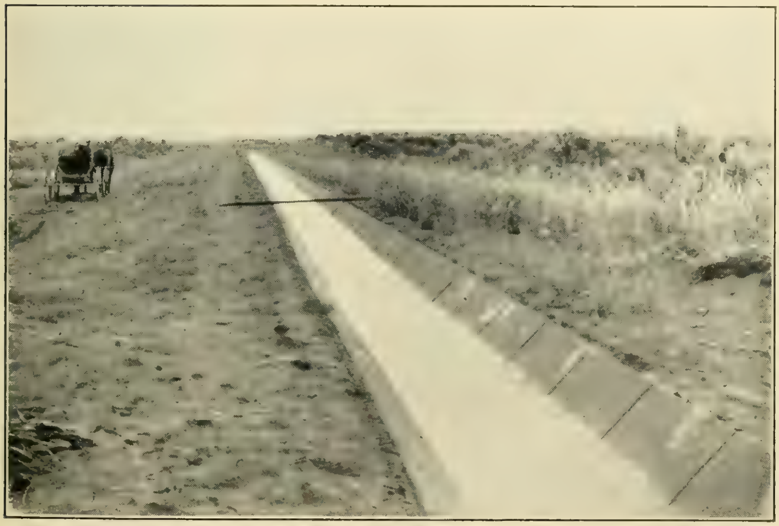


FIG. 2.—MORTAR-LINED LATERAL, UMATILLA PROJECT.

The foregoing records, while incomplete and faulty in many respects, are among the best obtainable in a new country, and in any event are instructive. The general problem of reservoir losses is often given less attention by engineers than its importance warrants. In many cases the dam site is apt to monopolize attention, and an engineer accustomed to deal with reservoir sites in Eastern river valleys, where the adjacent water-tables are high and the losses are generally confined to evaporation, may be led to the commission of grave mistakes. A great deal has been said and written about return flow. One of the writer's earliest recollections in connection with reservoir studies was the discussions in the *Transactions* of the Society between Messrs. FitzGerald, Stearns, Fteley, and others, on groundwater storage of certain reservoirs in the East. Mr. FitzGerald's conclusions as to the general inadvisability of giving credit to the invisible storage of a reservoir are wise. Save under exceptional conditions, the writer doubts whether much, if any, additional draft can be made from Western reservoirs in excess of the visible storage. During the past four years the Cold Springs Reservoir has absorbed some 30 000 acre-ft. of water in its bed; it has apparently yielded back only about 1 500 acre-ft. The Deer Flat Reservoir has absorbed apparently 270 000 acre-ft., with little or no return.

It is important to note that in a reasonably good, representative, irrigation reservoir, such as Cold Springs, one-quarter of the water turned into it is lost, and that, apparently, under the most favorable circumstances, as at East Park, 10% will be lost.

The main lesson to be derived from these few illustrations is that the geologic structure of the site should be given the most careful consideration, as it is vital to determine in advance, as nearly as may be, the amount of reservoir losses, and whether they are likely to be of a permanent character.

On the Umatilla Project, the cost of the irrigation works per acre of irrigable land is from $60 to $70; on the Truckee-Carson Project, about $40; on the Orland Project, about $50; on the Tieton, about $90; on the Sunnyside, about $50; and on the Klamath, from $30 to $40; say, an average of about $55. This is a fair indication of the general run of costs in large irrigation work in that part of the country, and is probably lower than the average costs on newer projects, either Government or private.

The various losses in the water-supply system, as expressed in percentages of water diverted, are as shown in Table 5.

TABLE 5.—PERCENTAGES OF LOSSES.

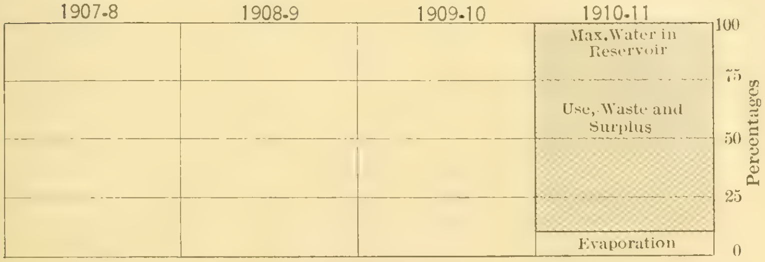
	Reservoir.	Canal losses.	Totals.
Umatilla	20	32	52
Truckee-Carson	0	41	41
Orland	8	23	31
Klamath	0	48	48
Tieton	0	24	24
Sunnyside	0	27	27

These losses, running from one-fourth to upwards of one-half of the whole supply, are, unfortunately, not all. They include only the losses from the diversions down to the end of the regular lateral systems operated by the Government; but below these are the ramifications of the small ditches built by the farmers to distribute water to their farms. These farm ditches are usually small earthen trenches, in which heavy seepage occurs before the water actually reaches the crop. In some cases farmers use water-tight flumes and pipes for their local distribution, but the proportion of these cases is as yet comparatively small, although on the increase. It has been estimated that seepage losses in the farmers' ditches on many projects is not less than 50% of the losses in the main canal and lateral systems. Allowing for the losses in the farmers' ditches not included in Table 5, the latter might be revised as shown in Table 6, it being understood that the losses in the farmers' ditches are merely the expression of individual opinion, not of actual measurement.

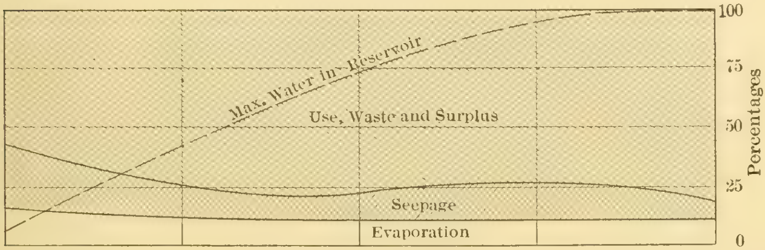
TABLE 6.—PERCENTAGES OF LOSSES.

	Reservoir.	CANAL LOSSES.		Totals.
		Canals and laterals.	Farmers' ditches.	
Umatilla	20	32	15	67
Truckee-Carson	0	41	15	56
Orland	8	23	10	41
Klamath	0	48	15	63
Tieton	0	24	8	32
Sunnyside	0	27	7	34

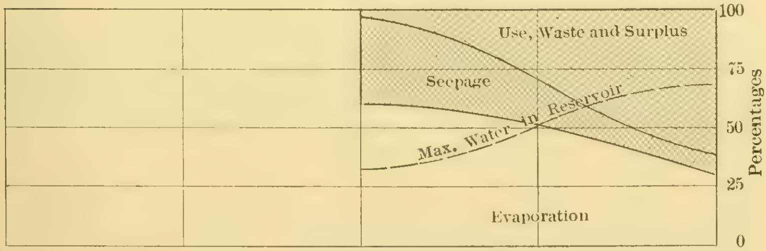
Seepage losses on the Umatilla Project early assumed serious proportions owing to the sandy character of the soil and the gravelly substrata. With the unlined earthen ditches, as originally constructed, only about one-third of the water diverted reached its proper



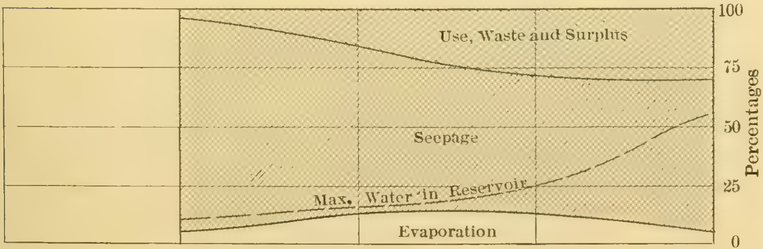
EAST PARK RESERVOIR, CAL.



COLD SPRINGS RESERVOIR, ORE.



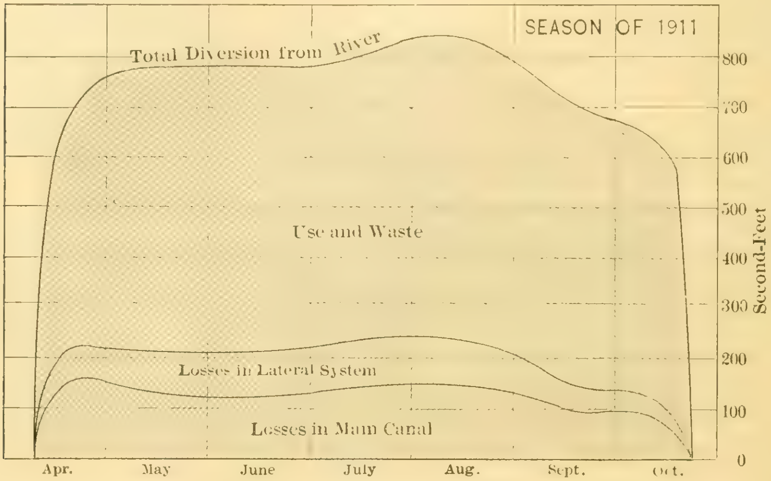
CLEAR LAKE RESERVOIR, CAL.



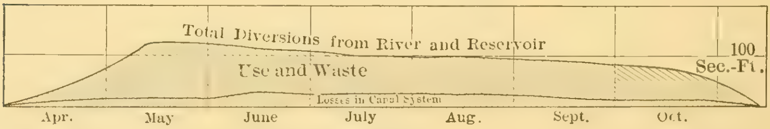
DEER FLAT RESERVOIR, IDAHO

FIG. 3.

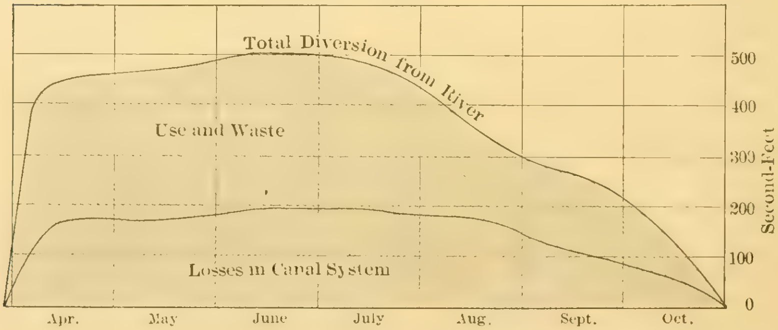
destination. The works were costly, and the quantity of the supply was limited. Unless means could be found to lessen these losses, it was evident that the entire area could not be irrigated, and the building costs would not be wholly repaid.



SUNNYSIDE PROJECT, WASH.



ORLAND PROJECT, CAL.

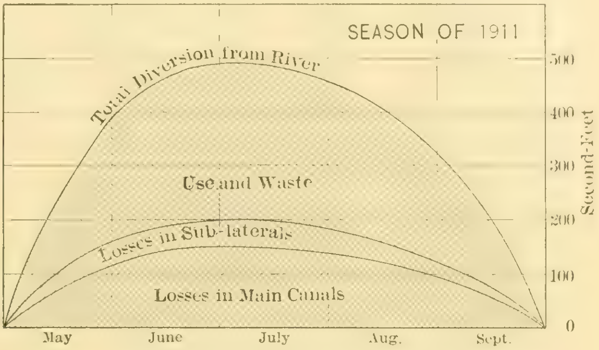


TRUCKEE-CARSON PROJECT, NEV.

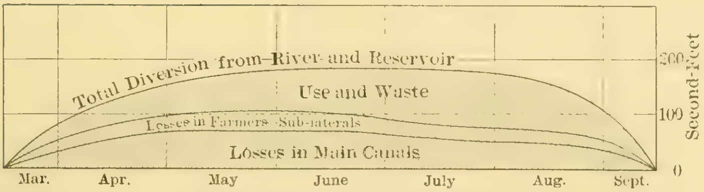
FIG. 4.

About equally severe proportional losses were found on the Truckee-Carson Project, in Nevada, and on the Klamath Project, in Oregon, but in both these projects there is more elasticity, due to their greater available supplies, and, in the case of the Klamath Project, to the small aggregate quantity used.

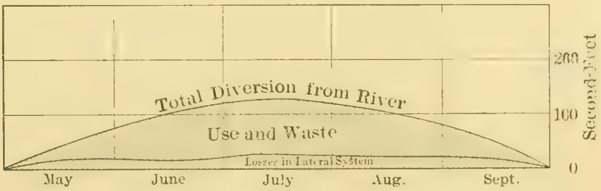
Losses on the Tieton and Sunnyside Projects are probably much more satisfactory than in the average well-constructed project in that vicinity, due, in the first case, to the complete concrete lining of the main canal and the tight character of the substrata of the irrigated lands. In the Sunnyside Project, the relatively small canal losses are due mainly to the fine texture of the soils.



KLAMATH PROJECT, ORE.-CAL.



UMATILLA PROJECT, ORE.



TIETON PROJECT, WASH.

Note;-Practically no losses in Main Canal

FIG. 5.

It is probably a fact that in the average project from 40 to 50% of the supply is lost by seepage in the beds of channels before it reaches the actual point of application. As the farmer is paying from $30 to $90 per acre for this water, the loss is very appreciable.

In Southern California valuable orchard lands have been under irrigation for a generation. Crop values have been very high, and, in many cases, the water supply has been so limited that effective measures toward conservation have been enforced. On many projects in that region the distributing channels are lined with concrete, or pipe is used liberally. The high values of lands and the scanty water supply have rendered these measures not only desirable but necessary. Strict economy in use has also been enforced, for the same reason, but, in the newer projects in the Northwest, where crops of lower values obtain, it has not hitherto been seriously regarded as feasible to resort to such expensive treatment. Conditions, however, have changed materially with regard to crop values, and many of the water supplies which appeared to be inexhaustible a few years ago are being rapidly fully appropriated, so that reasons for economy and waste prevention are becoming more and more cogent.

Some interesting experiments carried out under the auspices of the College of Agriculture of the University of California, in 1906, by B. A. Etcheverry, Assoc. M. Am. Soc. C. E., on various kinds of canal lining, including concrete, clay puddle, and oiled surfaces, are worthy of consideration. The object of these experiments was to determine relative costs and efficiencies of different classes of lining in reducing seepage and preventing the growth of vegetation. Without attempting to enter into the details of these experiments,* the general results showed that the concrete lining alone, although the most expensive, gave assured results. The oiling, as would be expected, is very much cheaper than any other treatment, costing only about one-quarter as much per square foot as concrete. During the first year it appears to be of some value in reducing seepage losses, measurements showing that the losses, as compared with those in an untreated earthen canal, are only about 40% of the latter. The oil seemed to be principally valuable in preventing a growth of vegetation. The clay puddle lining gave somewhat better results in preventing seepage

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* "Lining of Ditches and Reservoirs to Prevent Seepage Losses," *Bulletin* No. 188, Agricultural Experiment Station, University of California.

PLATE XCIX.
PAPERS, AM. SOC. C. E.
OCTOBER, 1912.
HOPSON ON
SEEPAGE LOSSES IN IRRIGATION SYSTEMS.

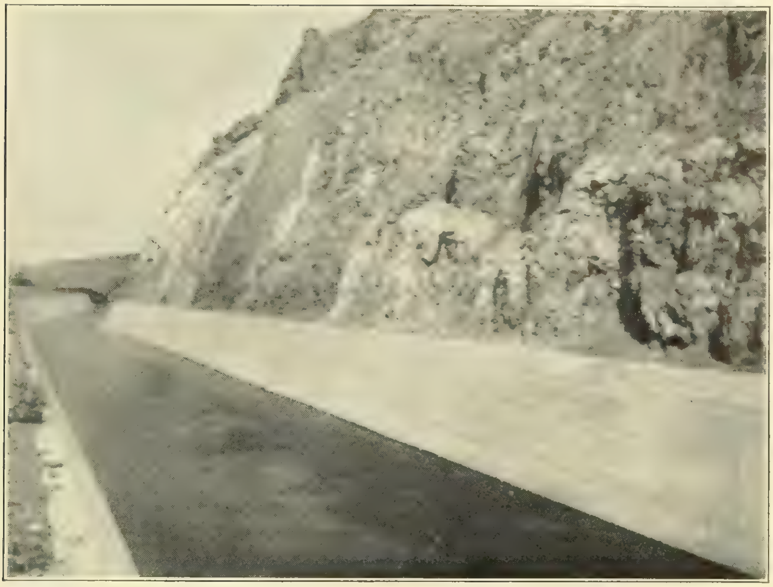

FIG. 1.—MAIN CANAL, TRUCKEE PROJECT, CONCRETE LINED.

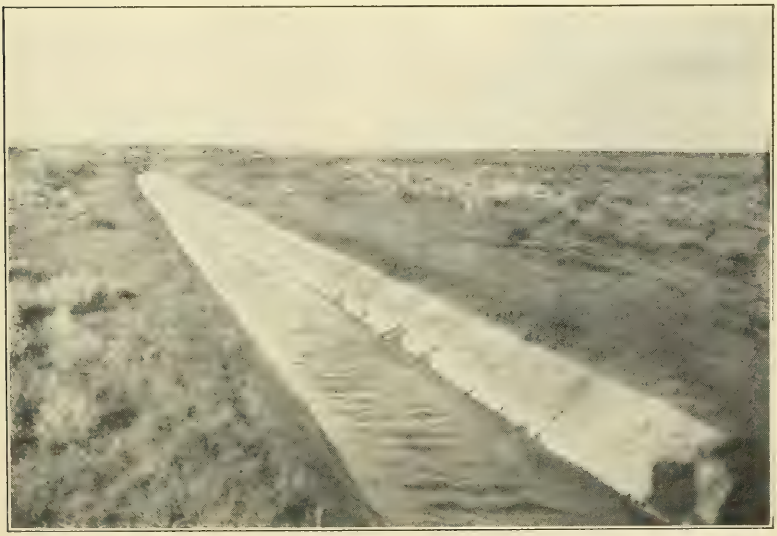

FIG. 2.—MORTAR-LINED LATERAL, UMATILLA PROJECT.

than the oiled surface. The mortar and concrete linings, however, prevented from two-thirds to nine-tenths of the total losses, and, of course, entirely stopped the growth of vegetation.

Apparently, the effect of the oil treatment is only temporary, and a year or two afterward, a re-examination of the canals in which the experiments were made showed that the growth of vegetation in the oil-treated canals was equal to that in those untreated, and in all probability the seepage losses were also as great.

In 1910 and 1911, a lateral on the Umatilla Project was lined with mortar, 1 in. thick, and careful measurements were made to determine the losses. The lateral had been selected for lining on account of the very porous character of its bed and in order to reduce seepage loss. With the lateral closed at the ends by dams, measurements showed that the water surface lowered about 0.1 ft. each day in the lined ditch, and by applying this rate of loss to the canal system as a whole, making due allowance for velocity of flow, it was computed that the aggregate seepage loss in the project, if all the canals were lined, would be about 5% of the supply. With the unlined system the loss is close to 50 per cent. Subsequent measurements have confirmed the above, and, from these and other data, the conclusion has been reached, that seepage losses can be kept down to less than 10% of the amount diverted, if good linings are placed.

During the past two years much canal and ditch lining has been placed on Government projects in the Northwest. These linings are from 1 to 4 in. thick, depending on the size of the canal and the conditions. The heavy linings are of regular sand and gravel concrete having about 1 part of cement to 8 parts of sand and gravel. They are generally placed without forms, the sides of the channel being trued up and a rather dry mix being used. The cost has usually been about $6 per yd. The great bulk of the ditch lining, however, has not been of regular gravel concrete but of mortar, which is usually composed of 1 part of cement to 4 parts of sand. Before placing the mortar the ditches are carefully trued up by running a movable form or templet along their courses, and wetting and tamping the earth around the form. Immediately after the form is removed, the mortar is placed and kept damp until it has set well. It is jointed usually at about 4-ft. intervals in order to take care of temperature shrinkage. This lining is done with much rapidity by experienced gangs. The materials are mixed in small portable gasoline-driven mixers, and the completed canals are kept full of water. The costs of work of this kind, carried out on a fairly large scale, for lining 1½ in. thick, reinforced at the top by an extra heavy curbing, run from 55 to 60 cents per sq. yd., inclusive of all administrative and engineering charges and of the earthwork. In general, the cost of the earthwork is about one-third of the entire cost.

Take, for example, a small lateral of the Umatilla Project lined in this way during 1911: The length was 12 400 ft.; the ditch dimensions were 4 ft. wide at the bottom, and 4 ft. deep, with side slopes of 1¼ to 1; the entire cost of the work averaged $1.05 per ft. Comparing a small ditch thus lined with an unlined one, the former will cost from three to four times more than the unlined ditch, but one of the economic advantages which the lined ditch possesses is the greater velocity of flow possible and the consequently smaller cross-sectional area of the channel. Another important advantage in lined ditches is the avoidance of drop structures. It is surprising what a large proportion of the total cost of ditch building goes into drop structures which are necessary in order to keep velocities below the eroding point in an earthen channel. With lined channels high velocities are not only possible, but desirable, in order to keep the channel clean.

As an illustration of what proportion the cost of structures in a distribution system bears to the entire expense of the latter, figures taken from the Orland Project in California are given. This territory is notably free from topographic irregularities, and the earth is firm and good for building purposes. The proportion of cost of structures, therefore, would be expected to be small.

The lateral system covers 14 000 acres, and includes 54 miles of ditches ranging in capacity from 12 to 75 sec-ft. Very little ditch lining has been placed, but the structures are all of concrete, the cheapest building material. The cost totals are as follows:

Excavation work	$64 376
Structures	57 632
Total	$122 008

PLATE C.
PAPERS, AM. SOC. C. E.
OCTOBER, 1912.
HOPSON ON
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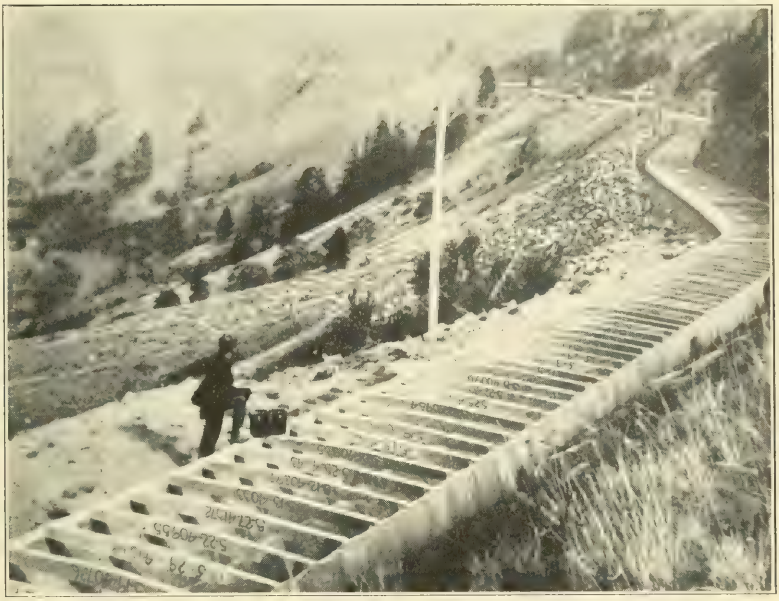

FIG. 1.—TIETON MAIN CANAL, CONCRETE LINED.

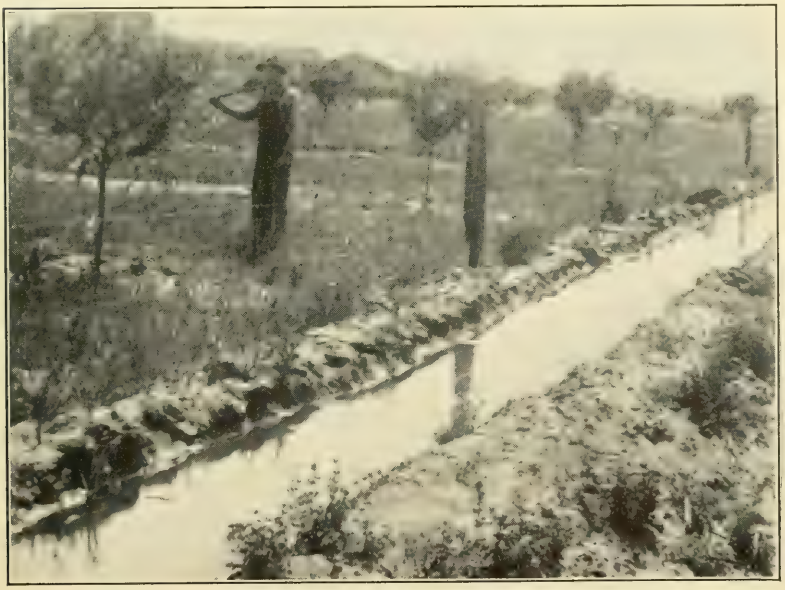

FIG. 2.—TYPICAL FARMERS' LATERAL, UMATILLA PROJECT.

The structures included in these cost totals comprise the following types:

Checks and drops	$20 885
Turn-outs	12 901
Bridges	9 972
Railroad crossings	6 924
Special structures	5 805
Spillways	1 143

Checks, drops, and turn-outs total $33 780, or 28% of the entire cost of the lateral system. All this cost could not be obviated by lining the system, but certainly a very large proportion could.

With a smaller cross-sectional area, the saving in drop structures, and the more direct and economical location possible in the lined ditches, the actual difference in cost per acre of land served by lined or unlined canals is comparatively small. It will generally be found to be less than $10 per acre, in many cases less than $5. If one takes into consideration the operating economies, the lined laterals have a distinct advantage by their freedom from breaks, seeped banks, and growth of vegetation in the channels, all of which should admit of a material reduction in operating costs. If these latter savings could be calculated from an investment standpoint and capitalized, any advantage in first cost of the unlined ditches would probably disappear, and a substantial margin be shown on the other side.

While considering canal lining, it would be well to give a little attention to the merits of pipe work in a distributing system. Large quantities of pipe have been used in the distributing systems of the Umatilla, Tieton, and Sunnyside Projects. The great bulk of this pipe is of concrete, both reinforced and plain, in sizes running from 54 in. down to 12 in. in diameter. The sizes below 24 in. have been usually made by the dry process, the reinforcement consisting of outside wire winding under tension. The larger diameters have usually been wet mixed, the pipe being manufactured in yards and hauled and laid like cast-iron pipe. Some of these lines of pipe are of great length and work under heads running up to 110 ft. They have always given satisfaction, from every standpoint. A distribution system consisting wholly of concrete pipe would be undoubtedly the most satisfactory from an operating standpoint, and although the first cost would be comparatively high, it might in the end prove to be more truly economical than the open-ditch system. With concrete pipe seepage losses are practically negligible. A number of tests of different lines of 4-ft. pipe, under operating conditions, show the following, all this pipe having a shell 3 in. thick:

	Length.	Head.	Average seepage per mile.
1	4 700 ft.	39 ft.	0.07 sq. ft.
2	5 400 "	28 "	0.05 " "
3	3 600 "	19 "	0.04 " "
4	9 800 "	85 "	0.20 " "

Apparently, the loss per mile in pipe of this size is nearly directly proportional to the head, and averages about 0.02 sec-ft. per mile for each 10-ft. head carried on the pipe. A pipe-distributing system of concrete throughout, under an average pressure head of 50 ft., with delivery to each 40-acre subdivision, would thus only lose about 1%, which is practically negligible.

Taking the average of the six projects quoted, the average cost of the irrigation works would be $55 per acre with an average combined loss in reservoirs and canals of about 50% of the entire water supply. Of the latter, about 6% is practically incurable reservoir loss; the remaining 44% has been classed as curable, that is, the great bulk of it can be cured or prevented if economical conditions render such action wise.

Should the ditch systems of these projects be wholly lined with concrete or pipe, the losses might be reduced from 44% to 10%, or less, a net saving of 34%, or, say, one-third of the whole supply. It is evident, therefore, that either the systems could be extended to cover about one-third more area, or if such land is not available, the works might be constructed of smaller dimensions and at less cost. In the case of works already built, the latter alternative is inapplicable, and is merely illustrative of what might have been done, but cannot be helped now. The lesson, however, should be applied to new work. In cases where new lands can be taken in under existing works, consideration should be given to the possibilities of extension by lining the present systems.

Suppose, for example, a project of 20 000 acres costing $55 per acre, or a total of $1 100 000; if, by lining the ditches, the irrigable area can be increased to 27 000 acres, there will be first an additional cost for the new laterals with lining, which has been found to be about $18 per acre in a fairly difficult country, or, for the 7 000 acres, an additional construction cost of $126 000 will be necessary. Secondly, there will be the cost of lining the present ditch system, covering 20 000 acres, which, taken at $12 per acre, would mean an added charge of $224 000. The gross cost of the extended project, therefore, would be $1 450 000, or an average cost of $54 per acre. This, apparently, does not result in a material reduction in the acreage cost, but the great advantage lies in rendering available for profitable use the larger areas of land, the conservation of the water supply, and the avoidance of drainage evils referred to later. As a matter of fact, the process of extending a project already constructed with unlined earth canals, by the subsequent lining of ditches, is always much more expensive than if constructed *de novo* with the entire system lined.

In the case of a proposed large extension of the Umatilla Project, it is planned to line the entire canal system from the head-works down to the minor ramifications of the distribution system delivering to each 40-acre subdivision. At no point in the system will the water be exposed to avoidable seepage loss, and when the head-gates at the reservoir are opened, the Government will have the assurance that more than 90% of the supply will actually reach the cultivated fields.

Closely connected with the question of canal losses is the drainage problem. On nearly every irrigation project large and frequently increasing areas will be found subject to the rise of ground-water. The principal contributing influence in most cases is the seepage loss from the lateral systems, although a proportion, of course, is due to over-irrigation of the fields. On the Sunnyside Project, in Washington, some 4 000 or 5 000 acres of the best land was seriously affected a few years ago, large areas having been practically forced out of cultivation. In this case the Government was compelled to build a deep channel at a cost of some $340 000, mainly for the purpose of affording an outlet to the surplus water. On the Minidoka Project, in Idaho, the drainage feature is one of the most serious problems. At Umatilla the seepage water accumulating below the project in the Umatilla River has increased the summer flow some 100 sec-ft., and has rendered necessary the excavation of extensive drainage ditches through the lower lands. At Klamath some $40 000 has been expended during the past three years on this account, and, on the Truckee-Carson Project, it is planned to expend not less than $400 000 in addition to the large sums already disbursed. There is no question that much relief from this increasing danger will be experienced by eliminating from the ground-water accumulations the bulk of the canal seepage. It is the writer's belief that, as time goes on, it may even be found necessary for legislatures to require canal systems to be lined or otherwise protected from seepage loss, not only in the interests of the investor and water user, but as a reasonable measure of conservation when water supplies are limited. As an engineering and business policy, it is well in the front rank, and should be considered by all who are building new works or operating and extending those already constructed.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

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SPECIFICATIONS FOR METAL RAILROAD BRIDGES MOVABLE IN A VERTICAL PLANE.*

By B. R. Leffler, M. Am. Soc. C. E.

The excellent paper and specifications for movable bridges by C. C. Schneider, Past-President, Am. Soc. C. E.,† though quite general, pertained mostly to the common swing bridge, or one which rotates about a vertical axis. The writer has felt the need of specifications covering railroad bridges movable in a vertical plane, which necessity was created by the third and fourth track work in progress on the railroad with which he is connected. The common swing bridge is not well adapted to more than two tracks. The writer knows of only two four-track swing bridges in operation.

There seems to be a real necessity among engineers for specifications covering movable bridges of this class. The engineer who has not given long and special study to this class, which is mostly handled by patentees, cannot give adequate consideration to the various designs presented to him under intense competitive conditions. These specifications are intended as an aid to his judgment.

It is not considered wise, at this time, to enter into a discussion of the relative merits of the various patented bridges, the purpose of the specifications being to aid in producing a first-class structure for any style which may be adopted.

Some unsettled technical questions are considered, such as stresses in wire ropes bent over a sheave, the rating and testing of electric

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*This paper will not be presented at any meeting, but written communications on the subject are invited for publication with it in *Transactions*.

† *Transactions*, Am. Soc. C. E., Vol. LX, p. 258.

motors, the character of the grooves for the lubrication of trunnions carrying heavy loads, the designing of keys and key-ways, etc.

The writer anticipates that the average mechanical engineer will not agree with the views on stresses in wire ropes. He believes that mechanical engineers use methods which are too loose (under the guise of so-called practical experience) in designing machinery parts. As generally used, wire rope is much over-stressed, principally by being bent over sheaves which are too small. Such practice may do where the rope is readily inspected and easily replaced, but wire rope for supporting counterweights in lift bridges should be designed by formulas which take into account the leading factors affecting the life and strength of the rope. A large factor of safety should then be used.

The rating of electric motors is that adopted by the American Institute of Electrical Engineers, in June, 1907. Some engineers specify a half-hour rating, which usually means a motor of the crane type. Motors for mill work are now being made, and are superior to any other type for strength and ruggedness; these are tested on the one-hour rating, and are suitable for bridge work.

Considerable care should be devoted to the design and workmanship of grooves in large trunnions for lubrication. The grooves should be large and allow of being cleaned. Compression grease cups should be used.

The design and workmanship of keys and key-ways do not usually receive enough attention, as keys come loose and cause damage and delay in the operation of bridges. Erectors sometimes use offset keys, made in the field, for adjusting the relative position of machine parts; but such keys are very objectionable. A key of minimum size, based on the diameter of the shaft and low unit stresses, has been specified.

Cut gear teeth are specified for wheels transmitting considerable power. This is somewhat unusual; but as most railroad bridges are not hand-operated, the resulting smoothness in the running of the machinery is desirable. Cut gears add a very small percentage to the total cost of a structure. The cutting of cast gears sometimes reveals defects which otherwise would remain hidden.

Two formulas are presented for the strength of shafting, axles, etc. This subject is not treated very clearly in works on machine design. The use of the term "equivalent twisting moment" is confusing. The formulas conform to the practice in structural designing of giving a value for tension or compression, and one for shear, respectively.

The writer believes that bridge engineers often specify too high a wind pressure. As usually specified for stationary structures, this includes an allowance for unknown lateral forces which are caused by a train moving over a bridge. Obviously, a smaller wind pressure should be specified for a bridge in motion. A pressure of 10 lb. per sq. ft. means, according to the formula, $P = 0.0032\ V^2$, a velocity of 56 miles per hour. The machinery should be able to hold the structure for a pressure of 15 lb. The wind pressure on a long bascule bridge is a large item.

Designers are sometimes too careless in their methods of designing machinery, relying mostly on rules-of-thumb or so-called experience. All resistance should be separately (and finally in their totality) considered. Coefficients should be adopted for the various sliding and rolling surfaces. The resistance of the moving span and attached parts should be reduced to a single force acting at the rack or in the operating cable. The motor torque for overcoming this resistance, and the machinery resistance, should be shown for all positions of the moving structure. The best method is to plot curves showing the torques, etc.; the time of opening, in 5- or 10-sec. intervals, should be plotted as abscissas, and the motor torque, resistance at rack, etc., as ordinates.

A moving structure is subject to some impact stresses due to its own motion, the magnitude of which cannot be found. The coefficients given simply express the writer's opinion.

No claim of originality is made for all parts of the specifications. The writer is largely indebted to Mr. Schneider's paper; to J. A. L. Waddell and J. L. Harrington, Members, Am. Soc. C. E., for workmanship and material for wire rope and attachments; and to others. To some extent his labors have been those of a compiler.

There is scarcely any first-class technical literature in the United States on the bending of wire rope.*

The writer has endeavored to make the specifications complete, but, of course, this was impossible. Some points are not covered, for instance, a specification should be framed to cover the design of segmental and track girders in rolling bridges, with special reference to taking care of the heavy concentrated load.

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* Attention is called to the article by Chapman, in the *Engineering Review*, London, October, 1908.

A rough test of the power required to open a double-track trunnion bridge of 159-ft. span, weighing, for parts in motion:

Machinery..............	156 877 lb.	
(Steel) Counterweight....	538 313 "	Counterweight truss-link plate.
Span....................	797 009 "	Operating struts.
Concrete	2 570 000 "	
	3 062 199 lb. = 1 531 tons.	

TEST OF POWER:

Controller notches.	Volts.	Amperes.	
1	212	150	Time required to open = 2 min. 20 sec.
2	210	200	
3	210	200	
4	210	250	
5	210	200	
6	210	190	
7	201	350	
8	201	225	
9	201	375	
10	201	300	
1	219	60	Time required to close = 2 min.
2	219	60	
3	219	60	
4	219	75	
5	219	75	
6	219	75	
7	205	250	
8	205	225	
9	205	200	
10	205	200	
Average of readings of another test.	205	240	Time required to open = 2 min. 15 sec.
	216	93	Time required to close = 2 min.

SPECIFICATIONS FOR BRIDGES MOVABLE IN A VERTICAL PLANE.

Scope.

1.—These specifications are intended to cover bascule bridges, which are such as rotate about a horizontal axis; and vertical lifts, which are those in which successive positions are parallel.

2.—The specifications of The New York Central Lines for Steel Railroad Bridges, for 1910, shall apply to movable bridges, except as noted herein.

Manner of Bidding.

Parts Classified as Machinery.

3.—Drums, cylinders, eccentrics, trunnions and their cast supports, shafting, pistons, gear wheels, racks, boxings, bearings, couplings, disks, cast sheaves and wheels, worm gearing, valves, pins about the axis of which the connecting members rotate, whistles, ram screws, end bridge locks, rail locks, indicators, cranks, axles, hooks, wrenches, and similar parts of machinery which require machine-shop work, shall be classified as machinery and be paid for at a common price per pound. Electric motors are not classified as machinery.

Sheaves.

4.—The large sheaves of vertical lift bridges, the webs and diaphragms of which are built up with plates, angles, and rivets, shall be paid for at a separate price per pound of finished weight including casings and fastenings to trunnions.

Air Compressor Boilers.

5.—Air compressor tanks and steam boilers shall be paid for at a separate price.

Wire Ropes and Cables.

6.—Wire ropes and cables shall be paid for at a separate price per pound.

Sockets, Pins, Levers, etc.

7.—The sockets, pins, equalizing levers, and cable attachments to the trusses and counterweights shall be paid for at a separate price per pound.

Structural Steel Parts.

8.—Structural steel supporting the machinery proper, counterweight frames, counterweight trusses, towers, and links shall be classified as structural steel and be paid for at the same price per pound as for the span itself.

9.—Structural steel which can be fabricated by the common shop methods as punching, reaming, drilling, shearing, planing, etc., as is usually done for stationary structures, shall be classified as structural steel and be paid for at the same price per pound as for the span itself.

Segmental Girders.

10.—Segmental girders in rolling bascule bridges and the horizontal girders on which they roll shall be paid for at a separate price per pound. This does not include any bracing, floor system, or other structural members which may be attached.

Electric Equipment.

11.—Electric equipment, such as wiring, switch-boards, controllers, lights, blow-outs, cut-offs, solenoids, switches, motors, etc., shall be paid for on a lump-sum basis.

12.—Cast-iron parts used in counterweights shall be paid for at a separate price per pound.

13.—Concrete in counterweights shall be paid for at a price per cubic yard in place.

Extra Parts, etc. 14.—It is to be understood that if any extra parts are needed, or any question arises, all difficulties shall be settled on the pound price basis as quoted and accepted for the parts in question.

General Details of Designing.

Self-Centering Devices. 15.—Self-centering and seating devices shall be used on the free ends of the moving span. Holding and forcing-down devices shall be used for the free ends of each truss.

Rail Locks. 16.—Designs for bridging the gap between the shore rails and moving rails shall be furnished by the Railroad Company. Loose rails will not be allowed.

Air Buffers. 17.—Air buffers shall be furnished at the free ends of the moving span.

Counterweights. 18.—The counterweights shall be easily adjustable. Usually, this shall be done by adding or taking away cast-iron parts, or small concrete blocks.

Stairways. 19.—Metal stairways, with $1\frac{1}{2}$-in. hand-rail, shall be provided, for access to the machinery, trunnions, and counterweights.

Girders in Rolling Bridges. 20.—The reinforcements of webs in the segmental girders and track girders of rolling bridges shall be symmetrical about the center planes of the webs. The center planes of the segmental webs shall coincide with the corresponding center planes of the webs of the track girders.

Coefficients of Friction for Moving Span and Attached Parts. 21.—In calculating the resistances to be overcome by the machinery, the resisting forces shall be reduced to a single force acting between the pinion and operating rack, or in the operating cable. In determining this force, the following coefficients shall be used in starting the span, and, except for the stiffness in cables, shall be reduced one-half after motion is begun:

For friction on trunnions	$\frac{1}{8}$
For rolling friction of rolling bridges	$\frac{1}{12}$
For stiffness in cables	$\frac{1}{200}$

Losses in Operating Machinery. 22.—In figuring the machinery losses between the operating rack or operating cable and the motor, the following coefficients shall be used: for the efficiency of any pair of gears, 0.94; for journal friction, 0.07. The losses of any worm gear shall be taken at 30% for an angle of thread 20° or more.

Time to Open. 23.—The time to open the bridge after the ends are released shall be as specified on the proposed drawing.

24.—The force necessary to overcome the inertia and produce acceleration and retardation for the time of opening shall be considered. The machinery shall be capable of stopping the bridge in 6 sec.; for this purpose, the coefficient of friction in the friction brake shall be taken at not less than 25 per cent.

Inertia.

25.—In calculating the dead-load stresses in the moving structural parts, for the various positions of the open bridge, such stresses shall be increased 25% as allowance for impact. For stationary structural parts (as towers, and supporting girders in rolling bridges), to which moving parts are attached, or on which such parts roll, 15% of the static load shall be added as impact.

Impact in Structural Parts.

26.—In structural steel parts, where a percentage of the dead load or static load is added for impact, the unit stresses for stationary structures shall be used; the impact percentages are an allowance similar to that provided by an impact formula for stationary railroad bridges.

27.—The allowance for impact in trunnions, cables, cable attachments, and machinery parts is taken care of by lowered unit stresses.

Impact for Machinery Parts, etc.

28.—The least wind pressure to be assumed in proportioning the machinery or moving parts shall be 15 lb. per sq. ft. on the exposed surfaces of the moving parts as projected on any vertical plane. The machinery shall be strong enough to hold the moving parts in any position for this pressure, and be capable of opening the bridge in the specified time at 10 lb. per sq. ft. wind pressure.

Wind Pressure.

28a.—On the ordinary open-floor bridge with ties, the exposed surface to wind shall be taken equal to 80% of a full quadrilateral the width of which is the distance from center to center of trusses and the length of which is that of the moving span.

29.—The Contractor shall make complete detailed drawings of the machinery, so that any other shop can take them and duplicate the machinery. No reference to patterns or individual shop practices will be considered in lieu of the complete drawings. These drawings shall show a general outline of the assembled machinery. The drawings shall be made on tracing cloth, each sheet 24 by 36 in. in outside dimensions. These drawings shall become the property of the Railroad Company on the completion of the job.

Detailed Drawings.

30.—The Contractor shall furnish an outline drawing of the machinery, on which are shown the forces acting on the gear teeth, the twisting moment and bending moment on shafts, and other necessary information for checking the strength of the machine parts. A tabulation of the formulas and methods of calculation shall be shown complete enough to allow them to be checked.

Outline Drawing of Machinery.

31.—The Contractor shall show by a drawing of curves the torque to be exerted by the motor or prime mover, as follows:

Torque Curves.

1. A torque curve for acceleration and retardation;
2. A torque curve for the frictional resistances;
3. A torque curve for any unbalanced condition of the structure;
4. A torque curve for the wind load;
5. A torque curve showing the greatest combination of resistances acting at any one time.

In figuring the friction at starting (this being twice the running friction), no acceleration of the moving mass shall be considered. This friction shall be considered as reduced to the running friction in the first second after the power is applied.

Center of Gravity.

32.—The Contractor shall check the location of the center of gravity of the moving span, including all parts attached thereto, and also the location of the center of gravity of the counterweight, including counterweight girders and trusses, by computations based on accurate weights calculated from shop plans. He shall submit duplicate sketches and copies of these computations accompanied by weight bills to the Railroad Company for approval.

Hand Operation.

33.—All bridges shall be equipped with hand-operating mechanism. The number of men and the time required to operate shall be estimated on the assumption that the force one man can exert on a lever is 40 lb. with a speed of 160 ft. per min. developing about $\frac{1}{5}$ h.p. For calculating the strength of the machinery, the power of one man shall be assumed as 125 lb., but 150 lb. shall be the minimum used and applied to the extreme end of a lever.

Operating Machinery.

34.—The parts shall be simple in design, and easily erected, inspected, adjusted, and taken apart. The fastenings shall hold the parts in place securely after they have been set.

Kind of Material.

35.—Rolled or forged steel shall be used for bolts, nuts, keys, cotters, pins, axles, screws, worms, piston rods, trunnions, and crane hooks, if any.

36.—Trunnions, pins, and shafting more than 3½ in. in diameter shall be of forged structural steel. Shafting 3½ in. or less in diameter may be of cold-rolled steel.

37.—Forged or cast steel shall be used for levers, cranks, and connecting rods.

38.—Cast steel, or forged steel, shall be used for couplings, end shoes, racks, toothed wheels, brake wheels, drums, sheaves, and hangers where the supported weight will cause tensile stresses. Large sheaves may be built of structural steel.

39.—Pinions shall be made of forged steel, and cut from the solid metal.

39a.—Pinions shall have not less than fifteen teeth.

40.—Sockets used for holding the ends of wire ropes shall be forged without welds, from the solid steel.

Cast Iron.

41.—Cast iron may be used in boxes for shafts 2 in. or less in diameter, and which obviously carry light loads. Other boxes shall be of cast steel.

42.—Cast iron may be used in eccentrics, cylinders, pistons, fly wheels, and parts of motors which are usually made of cast iron. Cast iron shall not be used for any trunnion or axle support.

Metal for Bushings.

43.—Phosphor-bronze, brass, and Babbitt metal shall be used for the bushing or lining of journal bearings and other rotating or sliding surfaces, to prevent seizing.

44.—Phosphor-bronze, only, shall be used for bushing for the trunnions of bascule and lift bridges, or in any large bearing carrying heavy loads.

45.—The bushings for large bearings, such as for trunnions and similar parts, shall be held from rotating in their casings. The force tending to cause rotation shall be taken as one-eighth of the load on the trunnion or bearing and as acting tangent to the surface between the back of the bushing and casing. It shall be practicable to take out the bushing when the trunnion is slightly lifted.

Castings.

46.—Castings which are to be attached to rough unfinished surfaces shall be provided with chipping strips. The outer unfinished edges of ribs, bases, etc., shall be rounded off, and inside corners filleted.

Bolts and Nuts.

47.—Bolts and nuts, up to 1½ in. in diameter, shall have U. S. Standard V-threads. Nuts and exposed bolt heads shall be hexagonal in shape, and each nut shall be provided with a washer. If the nut will come on an inclined surface, a special seat, the top surface of which is at right angles to the bolt, shall be cast or built up to receive the nut. Bolt heads which are countersunk in castings shall be square.

48.—Nuts which are subject to vibration and frequent changes of load shall have locking arrangements to prevent the gradual unscrewing of the same. If double nuts are used for that purpose, each nut shall be of the standard thickness. Nuts shall be secured by split pins put through the bolt.

Screws.

49.—Screws which transmit motion shall have square threads.

Tap-Bolts, Set-Screws, etc.

50.—Tap-bolts and stud-bolts shall not be used, except by special permission.

51.—Set-screws shall not be used for transmitting torsion to shafts or axles. They shall be used for holding keys, or other light parts, in place.

Collars. 52.—Collars shall be used wherever necessary to hold the shaft from moving horizontally. Each collar shall have at least two set-screws at an angle of 120 degrees.

Shaft Couplings. 53.—Shaft couplings, unless of the flexible kind, shall be of the flange type, or split muff with bolt heads and nuts countersunk.

54.—Couplings shall be keyed to shaft.

Keys. 55.—Gib-head or hooked keys shall be used for keying machinery parts to shafts, except where otherwise shown. The keys shall have the proportions shown in Fig. 1, in which d is the diameter of the shaft.

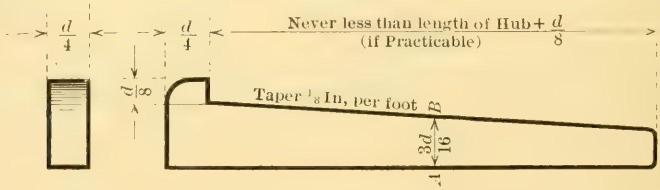
$\frac{d}{4}$
$\frac{d}{4}$
Never less than length of Hub + $\frac{d}{8}$ (if Practicable)
$\frac{d}{8}$
Taper $\frac{1}{8}$ In, per foot
B
$\frac{3d}{16}$
A

FIG. 1.

$A\ B$ is a mid-section of the tapered length. The sides shall be parallel.

56.—If the foregoing shape of key gives unit stresses in shear or bearing exceeding those in the table of allowable unit stresses, its section must be increased.

57.—The key shall be sunk in grooves in both hub and shaft. The finish of the grooves and key shall be such as to give a full bearing on all four sides, except as taper of key will not allow.

58.—If practicable, the groove in the shaft shall be made long enough to allow the key to be inserted without moving the wheel sidewise. After the key is firmly seated, the groove shall extend beyond the point of the key a distance not less than $\frac{3\,d}{8}$ to allow for future tightening; the clear distance between hub and hook of key shall not be less than $\frac{d}{8}$.

59.—The depth of the groove in the shaft shall be $\frac{3\,d}{40}$, measured at the side of the groove.

60.—In the case of large shafts carrying heavy parts, two or more keys of special design shall be used. In such cases, the matter shall be taken up with the Engineer, for special study.

61.—The foregoing requirements for keys and key-ways are for major machinery parts, the use of which is intended to develop the full torsional strength of the shaft. For minor parts, the keys and key-ways shall be proportioned for that size of shaft in which torsional strength would be developed by the minor parts.

Set-Screws for Keys. 62.—Keys shall be held in place by set-screws.

Hub. 63.—If practicable, the length of the hub shall be not less than $2d$. Its thickness shall be not less than $\frac{d}{3}$. The hub shall have a light driving fit.

64.—The groove in the hub shall be made on the center line of an arm.

65.—Hubs shall be bored truly at the center of the wheel.

Keys in Trunnions. 66.—For trunnions and similar parts, which are designed chiefly for bending and bearing, the keys, key-ways, and bolts shall be designed to hold the trunnion from rotating. The force tending to cause rotation shall be taken at one-fourth the load on the trunnion, and shall be taken as acting at the circumference of the trunnion.

Journals. 67.—Journals shall be proportioned to resist, not only the various stresses to which they are subjected, without exceeding the permissible fiber and bearing stresses, but also to prevent a tendency to heat and seize.

Bushings. 68.—Steel bearings carrying steel shafts or journals shall be lined with bronze or brass. If shafts are 3 in. or less in diameter and of a slow motion, Babbitt metal may be used. Bearings of steel on steel for moving surfaces will not be allowed.

68a.—Divided journal and trunnion bearings shall be used, and the cap shall be fastened to the base with turned bolts recessed into the base. The nuts and heads shall bear on finished bosses cast on the bearing.

Boxes. 69.—In cast-iron boxes carrying light shafts, no lining is needed.

70.—The bearings of shafts shall be placed as near to the points of loading as possible.

71.—The foot-steps of vertical shafts shall be of axle or tool steel, and shall run on bronze disks.

Lubrication. 72.—Provision shall be made for the effective lubrication of journals, or any other sliding surfaces. Closed oil or compression grease cups shall be used. Grooves shall be cut in the surface of the trunnion to provide for the proper distribution of grease or oil.

Grease Grooves. 73.—The grooves in large trunnions shall approximate to a **U** shape; the size shall be such that a wire $\frac{5}{16}$ in. in diameter may lie wholly within the groove. The edge of the **U** shall be rounded to a radius of $\frac{3}{16}$ in.

74.—The grooves shall be straight, running parallel to the axis of the trunnion. They shall be not less than three in number, and located so that all parts of the bearing surface of the bushing will be swept by the contained lubricant in an opening, and in a closing of the bridge. The grooves must allow of being cleaned with a wire.

Grease Cups. 75.—In any trunnion bearing, or similar heavy bearings, strong compression grease cups shall be used for the grooves.

76.—Oil and grease ducts shall be located so that the lubricant will flow by gravity toward the bearing surface.

Dust Covers.

77.—Dust covers shall be provided for principal bearings, in particular for trunnions.

Shaft Supports and Couplings.

78.—Line shafts, extending from the center of the bridge to the end, shall not be continuous, but shall be connected with claw couplings. Each length of shafting shall rest in not more than two bearings, with the couplings close to the bearings.

79.—If shaft supports are connected to the floor-beams, in bridges having long panels, intermediate supports shall be used; these shall be adjustable, and are intended merely to prevent the shaft from sagging.

Equalizing Gears.

80.—Equalizing gears or devices shall be used to insure equal action at the pinions and operating racks.

Unsupported Length of Shafts.

81.—The unsupported length of shafts shall not exceed $L = 80\sqrt[3]{d^2}$ for shafts supporting their own weight only; $L = 50\sqrt[3]{d^2}$ for shafts carrying pulleys, gearing, etc., where L = length of shaft between center of bearings, in inches; and d = diameter of shaft, in inches.

82.—Line shafts connecting machinery at the center to that at the ends shall run at fairly high speed. The speed reduction shall be made in the machinery near the end.

83.—In designing circular shafting, trunnions, and axles, the greatest unit fiber stress in tension or compression due to bending shall be calculated by the following formula:

$$f = \frac{32}{\pi d^3}\left(\frac{3}{8}M + \frac{5}{8}\sqrt{M^2 + T^2}\right).$$

Formulas for Shafts.

84.—The maximum unit shear shall be calculated by the following formula:

$$S = \frac{16}{\pi d^3}\sqrt{M^2 + T^2}.$$

85.—In these formulas, f = unit fiber stress in tension or compression; S = unit shear; d = diameter of shaft; M = the simple bending moment, and T = the simple twisting moment.

Effect of Key-Ways in Shafts.

86.—If a shaft, trunnion, or axle has one key-way cut, f and S shall be increased by one-sixth; if two key-ways are cut, increase by one-fourth. If the shaft, etc., is enlarged through the hub, this does not apply.

Distance Between Shaft Supports.

87.—In calculating the bending moment on shafts, trunnions, and journals, the distance from center to center of bearings shall be taken.

Style of Gear Teeth.

88.—Gear teeth shall be of the involute type, with an angle of obliquity of 20 degrees. The roots below the clearance line shall be filleted.

89.—The width of the teeth may be as great as four times the pitch, but not more, except for wheels running at a very high velocity, as in motors where abrasion is to be considered.

Strength of Beveled Gear Teeth.

90.—In estimating the strength of teeth in bevel wheels, the pitch at the middle section shall be taken.

Pitch Circle

91.—For the purpose of setting gear teeth accurately in the field erection, the pitch circle shall be scribed on the ends of the teeth.

Worm Gearing.

92.—Worm gearing, for transmitting power, shall have an angle of thread not less than 20 degrees. The worm shall run in oil. A bronze or brass collar shall be used at the end of the worm and at the end of the wheel axle, to take care of the end thrust. The wheel shall be of bronze. If a nut engages the worm, the nut shall be of bronze.

92a.—Worm wheels shall have not less than twenty-eight teeth.

93.—Worms which are to be used for actuating signals, indicators, or other minor parts may have an angle of thread less than 20 degrees.

93a.—Safety guards shall be provided around gears and other moving parts where it is necessary for workmen to be while the machinery is in motion.

Counterbalancing, Operating Ropes, and Attachments.

Wire Ropes and Cables.

94.—Wire rope shall be made by some manufacturer approved by the Engineer.

95.—The counterbalance ropes shall be of plow-steel wire, and shall consist of six strands, of nineteen wires each, laid around a hemp center.

96.—Ropes shall be laid up in the best manner, and shall be thoroughly soaked in an approved lubricant during the process of manufacture.

97.—The counterbalance ropes shall be made from wire which has been tested in the presence of an inspector, designated by the Engineer, and which, for sizes from 0.76 to 0.150 in. in diameter (the limiting values used in counterbalance ropes), exhibits the following physical properties:

a.—The tensile strength shall be not less than 225 000 lb. per sq. in. for wire from 0.150 to 0.126 in., nor less than 230 000 lb. for wire from 0.125 to 0.101 in. in diameter; nor less than 235 000 lb. for wire from 0.100 to 0.076 in. in diameter.

b.—The total ultimate elongation, measured on a piece 12 in. long, shall be not less than 2.4 per cent.

c.—The number of times a piece 6 in. long can be twisted around its longitudinal axis without rupture shall be not less than 1.4 divided by the diameter, in inches.

d.—The number of times the wire can be bent 90° alternately to the right and to the left, over a radius equal to twice its diameter, without fracture shall be not less than six. This test shall be made in a mechanical bender constructed so that the wire actually conforms to the radius of the jaws and is subjected to as little tensile stress as possible.

Ultimate Strength of Cables.

98.—The rope shall be made in one piece, if possible. Its breaking strength, as determined by the test described in Paragraph 101, shall be not less than

4 900 lb. if $\frac{1}{4}$ in. in diameter.
11 800 " " $\frac{3}{8}$ " " "
20 600 " " $\frac{1}{2}$ " " "
32 400 " " $\frac{5}{8}$ " " "
45 000 " " $\frac{3}{4}$ " " "
70 200 " " $\frac{7}{8}$ " " "
79 200 " " 1 " " "
100 800 " " $1\frac{1}{8}$ " " "
120 600 " " $1\frac{1}{4}$ " " "
148 000 " " $1\frac{3}{8}$ " " "
173 000 " " $1\frac{1}{2}$ " " "
200 000 " " $1\frac{5}{8}$ " " "
230 000 " " $1\frac{3}{4}$ " " "
264 000 " " $1\frac{7}{8}$ " " "
297 000 " " 2 " " "
325 000 " " $2\frac{1}{8}$ " " "
374 000 " " $2\frac{1}{4}$ " " "
465 000 " " $2\frac{1}{2}$ " " "

99.—In case the breaking strength of the rope falls below the values cited above, the entire length from which the test pieces were taken shall be replaced by the manufacturer with a new length, the strength and physical qualities of which come up to the specifications.

100.—Sockets used in connection with this rope shall be forged, without welds, from solid steel. In every case the dimensions shall be such that no part under tension shall be loaded higher than 65 000 lb. per sq. in. when the rope is stressed to its ultimate strength, as named above. The sockets must be attached to the rope by a method which is absolutely reliable and will not permit the rope to slip in its attachment to the socket.

101.—In order to show the strength of the rope and fastenings, a number of test pieces, not more than 10% of the total number of finished lengths which will be ultimately made, nor less than two from each original long length, and not more than 12 ft. long, shall be cut, and shall have sockets, selected at random from those which are to be used in filling the order, attached to each end. These test pieces are to be stressed to destruction in a suitable testing machine. Under this stress the rope must develop the ultimate strength given in Paragraph 98.

102.—The sockets must be fastened to the rope so that there is no slipping of the rope in the basket. If slipping should occur, then the method must be changed until one is found whereby slipping can be entirely avoided. The sockets themselves shall be stronger than the rope with which they are used; if one should break during the test, then two others shall be selected and attached to another piece of rope and the test repeated; and this process shall be continued until the inspector is satisfied of their reliability, in which case the lot shall be accepted. If, however, 10% or more of all the sockets tested break at a load less than the minimum ultimate strength of the rope given in Paragraph 98, then the entire lot shall be rejected and new ones shall be made of stronger material.

Length of Rope.

103.—The length of each rope, from inside of bearing to inside of bearing of sockets, shall be determined, and a metal tag having the said length stamped thereon shall be securely attached to the rope.

104.—The purchaser reserves the right to test each wire rope connection, after its attachment is made, up to one-half of the ultimate strength of the rope, and, if it shows the least sign of weakness, it shall be rejected and replaced.

Facilities for Testing Rope.

105.—The manufacturer shall provide proper facilities for making the tests, and shall make at his own expense all the tests required. Tests shall be made in the presence of an inspector who represents and is paid by the Engineer.

Shipment of Rope in Coils.

106.—Ropes shall be shipped in coils the minimum diameter of which is at least thirty times that of the ropes, and they shall be uncoiled for use by revolving the coil, not by pulling the rope away from the stationary coil.

Equalizing Levers.

107.—The equalizing levers connecting the ropes to the counterweights and their pins more than $3\frac{1}{2}$ in. in diameter shall be of forged steel; pins $3\frac{1}{2}$ in. in diameter or less shall be of rolled machinery steel. The levers shall be neatly finished, and shall conform to the dimensions shown on the drawings.

WORKMANSHIP.

108.—For the parts of the operating machinery of movable bridges which are usually exposed to the weather, the finish shall be confined to the bearing, rotating, and sliding surfaces, and wherever it is required to produce accurate fits and precise dimensions.

109.—Castings shall be cleaned, and seams and other blemishes removed.

110.—Drainage holes, not less than $\frac{3}{4}$ in. in diameter, shall be drilled in places where water is likely to collect.

Play in Unfinished Bolts.

111.—Unfinished bolts may have a play of $\frac{1}{16}$ in. in the bolt holes. Turned bolts must have the diameter of the shank at least $\frac{1}{16}$ in. larger than the diameter of the threaded portion, and must have a driving fit in the bolt hole.

Racks and Contact Surfaces.

112.—The backs of racks and contact surfaces shall be planed.

Tread Plates. 113.—The top and bottom of the tread plates and contact surfaces in rolling bridges shall be planed to fit. A full bearing must be made.

114.—The periphery and the ends of teeth which mesh with a shrouded pinion shall be planed, and the pitch line scribed thereon.

115a.—The joints between the caps and bases of journal and trunnion bearings shall be planed. The ends of the bases and surfaces in contact with the supports shall be planed. Bolt holes for holding the cap to the base and for holding the base to its support shall be drilled.

Finishing of Trunnions, etc. 115.—Journals and trunnions shall be turned with a fillet at each end and at points where the section changes. Trunnions and journals 8 in. and more in diameter shall have a hole, 1½ in. in diameter, bored through on the longitudinal axis. Journals, trunnions, and bushings must be polished after being turned. The use of a cutter which trembles or chatters will not be allowed.

Grooves. 116.—The grooves in the surfaces of trunnions or similar large bearings shall be machine cut. Chipping and filing will be allowed only for removing small inequalities. The grooves shall be smooth, especially the rounded corners.

Hubs. 117.—Hubs of wheels, pulleys, couplings, etc., shall be bored to fit close on the shaft axle. If the hub performs the function of a collar, the end next to the bearing shall be faced. Holes in hubs of toothed gear wheels shall be concentric with the pitch circle.

Cut Gears, etc. 118.—The periphery of gear wheels shall be turned. Gear wheels which are part of the train which actuates the moving span, or the bridge locks, or the rail locks, shall be cut. Machine-moulded teeth may be used for actuating signals or small parts.

Beveled Gears. 119.—Beveled gears shall be cut. The cutting shall be done by a planer having a rectilinear motion to and from the apex of the cone. Rotating milling cutters shall not be used.

Grooves in Sheaves. 120.—The grooves in the circumference of sheaves carrying wire ropes shall be turned to a radius which will fit the rope. This is to be done after the sheave is completely assembled and permanently riveted up.

121.—At the juncture of the shrouding and teeth in pinions, cleaning, chipping, or other means shall be used to insure the meshing of the pinion teeth and rack teeth.

122.—Threads on worms, and the teeth of worm wheels shall be cut and shall fit accurately. Point contact shall be avoided.

123.—Any two surfaces which slide, roll, or bear on each other shall be planed.

Assembling of Machinery. 124.—Machinery parts shall be assembled on the supporting members in the shop, and shall be aligned and fitted, with holes in the supports drilled, and with the members in correct relative position. The members shall be match-marked both to the supports and to each other, and re-erected in the same relative position; or, if not assembled in the shop, connecting holes in the supports shall be drilled in the field.

Holes for Sheaves for Vertical Lift Bridges.

125.—The holes in the girders and columns for the bolts connecting the main sheave bearings to their supporting girders shall be drilled from the solid through cast-iron or steel templets on which the bearings were set and accurately lined when the holes in the bearing were bored. The bolt holes and the bolts shall be turned to the same diameter and the bolts driven to place without injury to them, the bearings, or the girders or columns.

Shop Test on Trunnions.

126.—If trunnions rotate in fixed pedestal bearings, such as the sheave trunnions in vertical lift bridges or similar bearings, the pedestals shall be firmly mounted in the shop, the trunnions placed therein and covers bolted, the whole, when assembled, shall simulate the assemblage in the field as nearly as practicable. The maximum torque in inch-pounds required to rotate the trunnion shall be $\frac{W\,r}{10}$, where W equals the weight of the trunnion, in pounds, and r equals the radius of the trunnion, in inches. If large structural parts rotate about the axis of the trunnion, the trunnion shall be inserted in its bushing in the structural part and rotated. If the shop position of the structural part is flat, which is the usual case, the axis of the trunnion will be vertical, and there will be no load on the bearing; in this case the maximum torque required to rotate the trunnion shall be $\frac{W\,r}{50}$. At least four complete rotations of the trunnion must be made. If any grinding or hard turning is found, it must be remedied. These trunnion tests shall be made in the presence of the Railway Company's inspector and with such apparatus as will readily determine the torque.

Facing of Couplings.

127.—Faces of flange and split muff couplings shall be planed to fit. The couplings shall be keyed to the shaft.

128.—A special effort to secure good workmanship on keys and key-ways shall be made.

Coating of Surfaces.

129.—Machined surfaces shall have a coating of white lead applied to them.

130.—Machinery which is of the regular standard manufactured type, such as steam, gasoline, electric motors, pumps, air compressors, etc., shall be guaranteed by the manufacturer as to efficiency, and shall be subject to the approval of the Engineer. Motors shall be tested to prove that they fulfill the specified requirements and develop the desired speed, power, and torque.

Brake Test of Motors.

131.—The rating of a motor shall be the horse-power determined by the brake test.

A. I. E. E. Rules.

132.—The electric equipment shall conform to the Standardization Rules of the American Institute of Electrical Engineers, as approved June 21st, 1907. (See "Standard Hand Book for Electrical Engineers," 3d Edition, Sect. 19.)

133.—The unit stresses per square inch, to be used for parts in which main stresses are not increased by impact, shall be as follows:

STRESSES IN ONE DIRECTION, IN POUNDS PER SQUARE INCH.

Material.	Tension.	Compression.	Fixed Bearing.	Shear.
Machinery steel.........	9 400	$9\,400 - 40\,\frac{l}{r}$	11 000	6 200
Structural steel..........	8 500	$8\,500 - 36\,\frac{l}{r}$	......	5 600
Steel castings...........	7 000	$8\,000 - 35\,\frac{l}{r}$	......	5 000
Phosphor-bronze.........	6 600	....	......	4 600
Cast iron	3 000	8 000	......	3 000
Shear on keys...	.....	4 900 lb.		
Bearing on keys.	.....	8 800 "		

134.—The maximum unit tension in plow-steel cables shall be one-sixth of the ultimate. The maximum unit tension is equal to the direct unit stress plus the extreme fiber unit stress in the individual wire due to bending over the sheave.

Reversal of Stresses.

135.—For stresses which are reversed at the rate of five or more times per minute, use one-half of the above unit stresses.

136.—If wire rope is bent over a sheave, the bending stress and permissible load on the rope shall be calculated as follows:

Let P = the total pull or permissible load, on the rope, in pounds;
K = extreme unit fiber stress in the greatest individual wire;
E = modulus of elasticity = 28 500 000;
a = cross-sectional area of rope, in square inches;
d = diameter of thickest wire, in inches;
D = diameter of sheave to center of rope, in inches;
S = greatest unit tension allowable;
α = angle of helical wire with axis of strand;
β = angle of helical strand with axis of rope;
c = diameter of rope.

$$\text{Then } K = \frac{Ed \cos.^2 \alpha \cos.^2 \beta}{D} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$P = a\left(S - \frac{Ed \cos.^2 \alpha \cos.^2 \beta}{D}\right) \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

For rope having six strands of nineteen equal wires each,

$$P = a\left(S - \frac{1\,800\,000\,c}{D}\right) \dots\dots\dots\dots\dots\dots \quad (3)$$

because $cos.^2\ \alpha\ cos.^2\ \beta = 0.95$, $d = \frac{c}{15}$.

137.—For haulage rope, six strands of seven wires each, take $d = \frac{c}{9}$.

138.—If a rope is in contact with a sheave over a small arc, the actual radius of curvature may be greater than that of the sheave. (Fig. 2.)

Let R = the actual radius of curvature;
θ = the angle between the directions of the rope;
W = pull on individual wire, equal to P divided by the number of wires if all wires are of equal diameter.

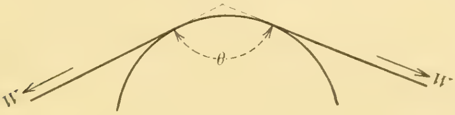

FIG. 2.

Then
$$R = \frac{d^2}{4\ cos.\ \frac{\theta}{2}}\sqrt{\frac{E}{W}}$$

139.—If R is greater than the radius of the sheaves, $2R$ should be used in place of D in Formulas 1, 2, and 3. The formula is only valid for θ between 110 and 180 degrees.

140.—The strength of cut gear teeth shall conform to the following formula, one tooth only taking pressure:

Strength of Gear Teeth.

$$P = fpb\left(0.154 - \frac{0.912}{n}\right)\frac{600}{600 + V}, \text{ in which}$$

P = pressure on tooth, in pounds;
f = permissible unit stress = 17 000 lb.;
p = pitch, in inches;
b = face or breadth of tooth, in inches;
n = number of teeth in gear;
V = velocity on pitch circle, in feet per minute.

141.—The strength of machine-moulded teeth shall be calculated by the foregoing formula, taking f = 15 000 lb.

142.—The strength of shrouded teeth shall be computed as for uncut teeth, the purpose of the shrouding being to provide for future wear of pinions.

143.—The foregoing formula is for involute teeth having an angle of obliquity equal to 20 degrees.

Pressure on Rollers.

144.—The pressure, in pounds per linear inch, on rollers at rest shall be, for rolled and cast steel, 600 d, where d equals the diameter of the roller, in inches.

Unit Stresses for Bearing on Rotating and Sliding Surfaces.

145.—The maximum bearing values for rotating and sliding surfaces, in pounds per square inch, shall be as follows:

For bearings on which the speed is slow and intermittent:

	Pounds per square inch.
146.—Pivots for swing bridges: Hardened tool steel on special phosphor-bronze	3 000
147.—Trunnion bearings on bascule bridges: Axle steel on phosphor-bronze, average	1 500
and never greater than 1 700 lb. for maximum bearing for any position of the bridge.	
148.—Wedges: Cast steel on cast steel or structural steel	500
149.—Screws which transmit motion on projected area of thread	200
150.—For ordinary cases, parts moving at moderate speeds:	
Hardened steel on hardened steel	2 000
Hardened steel on bronze	1 500
Tool steel (not hardened) on bronze	900
Structural steel on bronze	600
Cast iron on structural steel	400
Cast iron on cast iron	400
On cross-head slides, speed not exceeding 600 ft. per min.	50

151.—In order to prevent heating and seizing at higher speeds, the pressure on pivots or foot-step bearings for vertical shafts and journals shall not exceed:

$$\text{On pivots} \ldots\ldots\ldots p = \frac{40\,000}{n\ d} \text{ per square inch.}$$

$$\text{On journals} \ldots\ldots p = \frac{300\,000}{n\ d} \text{ per square inch.}$$

Where n = number of revolutions per minute,
and d = diameter of journal or pivot, in inches.

152.—For crank pins and similar joints with alternating motion, the limiting bearing values given in the above formula may be doubled.

Stresses on Rollers.

153.—The permissible pressures, in pounds per linear inch of roller in motion, shall be as follows:

For cast iron .... $p = 200d$
For steel castings .... $p = 400d$
For axle steel .... $p = 500d$
For tool steel .... $p = 800d$
For hardened tool steel.................. $p = 1\,000d$

Where p = pressure per linear inch of roller,
and d = diameter of roller, in inches.

154.—The foregoing values are for rollers and bearing surfaces of the same material; if rollers and bearing surfaces are of different materials, the lower value shall be used.

Motors.

155.—The kind of motor best adapted to any particular case depends on local conditions, and should be left to the judgment of the Engineer.

Mechanical Power.

156.—If the bridge is operated by mechanical power, the motor shall be of ample capacity to move or turn the bridge at the required speed. All machinery parts shall be designed with sufficient strength to resist the greatest pressure which can be exerted by the motor. No matter what mechanical power is used, all bridges shall also be provided with hand-power operating machinery.

Friction Brakes.

157.—Friction brakes, to be operated by hand or foot, shall be provided where the motor is located in the operator's house. They shall be attached to the secondary shaft of the motors which connect to the moving gear, and shall have sufficient capacity to stop or hold the moving span in any position, under all conditions.

Operator's House.

158.—If mechanical power of any kind is to be used for operating a movable bridge, a suitable house shall be provided for the operator. The house shall be of such dimensions as required for the purpose for which it is to be used. It shall be placed in a position where the operator can observe the signals and see the approaching vessels and trains, and with enough windows of sufficient size, so that this view will not be obstructed. If the operator's house is above or below the floor of the bridge, suitable steel or iron stairs with railings shall be provided to lead from the floor of the bridge to the floor of the operating house. The house shall be of fire-proof construction, consisting of a steel frame, steel floor-joists and a fire-proof floor. If the house contains motors and machinery, the floor shall preferably consist of steel plates, but, if the motors are located elsewhere, the floor between the joists may be of concrete construction. The sides and roof shall be of metal, concrete or any other non-combustible material. The hand-rail for stairways and other plates shall be of 1½-in. gas pipe.

Heating of Operator's House. 159.—Whenever the climatic conditions require it, provision shall be made for heating the operator's house. If steam power is used, the house shall be heated by a steam coil or radiator fed from the boiler. If electric power is used, the heat may be supplied by electricity. If gasoline is used, or any other power which cannot be utilized for heating, a coal, wood, petroleum, or gas stove, as directed by the Engineer, shall be provided.

Steam Engine. 160.—If a steam engine is used, it shall consist of a double-cylinder, reversing engine, the piston speed of which shall not exceed 200 ft. per min.; it shall develop the desired power and speed with a steam pressure of 50 lb. per sq. in. The engine shall be connected to the operating machinery by an approved friction clutch, arranged so that the moving and locking machinery can be operated alternately or stopped without stopping the engine.

Steam Separator. 161.—In the steam supply pipe, and close to the steam chest, shall be placed a steam separator. This separator, under test with quality of steam as low as 66%, shall show an average efficiency of 85% in five tests.

Boilers. 162.—The steam shall be generated by one or two upright, tubular boilers, each of which shall have twice the capacity of the engine. The boilers shall be designed for a steam pressure of 150 lb. per sq. in., and shall be adapted to the kind of fuel specified by the Engineer; they shall be of open-hearth steel in accordance with the specifications for boiler plates, Paragraphs 246 to 251, inclusive. They shall be encased in asbestos and covered with Russia iron.

163.—The boilers shall also be in accordance with the specifications of the Mechanical Department of the Railway Company, and shall conform to the civil laws.

Flues of Boilers. 164.—Vertical boilers shall have submerged flues at the top.

Horse-Power of Boilers. 165.—The total horse-power of the boilers shall be twice that of the engine, and shall be computed by the following rule: Calculate the inside area of the tubes, the area of tube sheet next to the fire, and the sides of the fire-box where this is in contact with the fire. Take the sum of these areas in square feet and divide by fifteen. The intention is to allow 15 sq. ft. of heating surface per horse-power. At least ⅓ sq. ft. of grate surface shall be provided per horse-power.

Equipment of Engine-Room. 166.—The engine-room shall be provided with a steel water tank of sufficient capacity; a duplex, steam feed-pump; and an injector for each boiler, with necessary pipes and connections for feeding boilers separately or together; steam water-lifters with necessary strainers, flexible hose, and piping to lift the water from the river into the tank; a coal hoist and a steel coal-bin of sufficient capacity. The engine-room shall be provided with a suitable indicator for recording the positions of the moving span in turning and locking. A work-bench with a full set of machinist's tools shall be provided, such as a vise, wrenches, chisels, hammers, files, oilers, oil-cans, and oil-tank.

Whistle.

167.—A whistle having a bell 5 in. in diameter and 12 in. long, shall be installed complete. If operated by air, the compressor and air tank shall conform to the following specifications: The compressor shall be motor driven, the motor and compressor being on one frame, and geared. All working parts shall be completely enclosed, and self-lubricating. The compressor shall have a piston displacement of from 25 to 30 cu. ft. per min. when working against a tank pressure of 90 lb. per sq. in. The compressor shall be provided with strainer, and automatic governor and switch, in order that the compressor may start and stop automatically at any predetermined tank pressure. The air receiving tank shall be 36 in. in diameter and 8 ft. long, or of equal capacity. The tank shall be galvanized, and good for a working pressure of 100 lb. per sq. in. It shall be provided with pressure gauge and pigtail, pop-valves and drain cock, and have standard flanges bushed for 1½-in. pipe. The Contrator shall furnish all pipe, pipe fittings, and valves, and all shall withstand a working pressure of 100 lb. per sq. in.

Gasoline Motor.

168.—If a gasoline motor or other internal-combustion motor is used, a low-speed engine of the most substantial kind shall be selected, the maximum piston speed of which shall not exceed 350 ft. per min. The engine shall have a reversing gear provided with approved friction clutches, to be operated by a hand-wheel. The countershaft connecting the engine with the operating machinery shall be provided with disengaging couplings, arranged so that the moving and locking machinery can be operated alternately and in either direction without stopping the engine. Motors of 10 h.p. and more shall be started by compressed air. The engine-room shall be provided with a water tank of sufficient capacity. The gasoline tank shall be located outside of the engine-house. The engine-room shall be provided with indicators for recording the positions of the moving span, and lifting and locking apparatus. A work-bench with a full set of machinist's tools, etc., shall be provided, the same as specified for steam engines.

Electric Motors.

169.—Electric motors and generators, if for direct current, shall be of the railway series, interpole type, water-proof, with slotted-drum armature, and form-wound armature coils. They shall be a standard commercial type in common use.

170.—The coils shall be impregnated.

171.—Motors, generators, automatic circuit breakers, solenoids, brakes, and other electric mechanism shall be tested at the factory by the manufacturer in the presence of the Railway Company's inspector.

Testing of Motor.

172.—The rating of a direct-current motor is the horse-power output at the armature shaft which gives a rise of temperature above the surrounding air (referred to a room temperature of 25° cent.) not exceeding

90° cent. at the commutator and 75° cent. at any other part after one hour's continuous run at its rated voltage (and frequency in the case of an alternating-current motor) on a stand with the motor covers removed and with natural ventilation. The rise in temperature is to be determined by thermometer, but the resistance of no electric circuit in the motor shall increase more than 40% during the test.

173.—Direct-current motors shall be capable of carrying a load of 200% for 3 min. with the same temperature rise and momentarily of 400% without injury, starting cold in each instance.

Torque of Motor. 174.—The motors under test shall develop the required horse-power and torque at the armature shaft. Characteristic curves showing the results of the test shall be furnished by the manufacturer.

175.—The motor frame shall have two bearings for the countershaft and shall have a forged-steel cut pinion, out of one piece, keyed to the end of the armature shaft and secured by a lock-nut.

175a.—If the motor is enclosed in a case, as mill motors are, small openings of sufficient size shall be provided in the case for the inspection, removal, and replacing of brushes.

176.—One cast-steel cut gear, bored and key-seated for attachment to the countershaft, shall be furnished with the motor. The gear and pinion shall be covered by a sheet-steel or malleable-iron split gear case, supported by the motor frame and completely covering the gear and pinion. An opening, with a hinged cover, shall be provided in the gear case for inspection and oiling. The gear ratio shall be such that the full speed of the countershaft will not be more than 125 rev. per min.

Spare Motor Parts. 177.—For each size of motor furnished, the Contractor shall supply the following spare parts: One armature, one field coil, one pinion, one gear, and one set of brushes. These parts shall be finished and fitted in such a manner as to admit of being installed in their respective places without further fitting or adjustment.

Mounting Motors. 178.—The motors shall be mounted in such a manner as to admit of easy access for inspection and repairs; they shall be supported securely by brackets or suitable foundations.

179.—If the machinery and motors are on the moving span, they shall be capable of being operated satisfactorily in any position of the span.

Controllers. 180.—The controllers for motors shall be located in the operating-house. The controllers shall be of the reversing drum type, with magnetic blow-out, and shall be capable of varying and maintaining the speed of the motors throughout the entire range desired, without injurious sparking, and without shock due to sudden variation in speed. The controllers shall be capable of doing their work for the usual loads, and excess loads, that may come upon the motors, with a temperature rise not exceeding that specified for the motors.

181.—One controller with the necessary resistances shall be furnished for controlling the operation of each main operating motor. They shall be connected so that the motors may be operated together.

Type of Controllers.

182.—The controllers shall be of the series-parallel type; or of the type in which the field is varied, as may be done for the interpole type of motor.

Controllers, Where Needed.

183.—One controller for direct-current motors shall be furnished for the operation of the rail locks, and one for bridge locks. These controllers shall be designed so that the operation of any motor can be cut out by pulling a switch on the switch-board, without affecting the operation of any of the other motors.

Automatic Cut-Offs.

184.—An automatic cut-off or short-circuiting device shall be provided which will throw out the circuit breakers, cut off the current from the operating motors and set their brakes when the bridge is 5° from its open position, and its closed position. Spring switches shall be provided which, if closed and held closed, will put the cut-offs out of commission and thus enable the bridge tender to fully close or open the bridge.

185.—The end lock motor shall be stopped and its brake set automatically at each end of its travel.

Resistances.

186.—Resistances shall be of the cast-grid type, and of such capacity that the motor can be operated continuously at any point of the controller when developing full-load torque, or for 10 min. when developing 50% over-load torque, without sufficient rise in temperature of the resistance to cause deterioration of any part. The resistances shall be mounted so as to admit of free ventilation and be without injurious vibration.

Electric Brakes.

187.—The main operating motors, rail lock motors, and bridge lock motors shall be provided with approved post brakes which are held in set position by a spring with such force as to overcome not less than 50% of the maximum torque required. The friction surfaces are to be of materials not affected by moisture. The brakes are to be released by solenoids of ample power and heating capacity whenever the motors are taking current, and are to be automatically set whenever the current fails or is cut off from the motors. Weather-proof motors shall be provided with weather-proof solenoids. Brakes shall be provided with a foot-switch release for coasting purposes. Means shall be provided for mechanically releasing the brakes when the bridge is to be operated by hand or other equipment.

Emergency Brakes.

188.—An additional emergency brake shall be provided and applied to the main operating machinery. This shall be released by means of a motor-operated mechanism furnished by the Eectrical Contractor, which shall hold the brake in release as long as the current is applied to the brake motor. Cutting off the current from this brake motor, or any failure of current, will result in the instantaneous application of the brake. This brake will be normally set, but will be released by the operator before starting the bridge, and be held in release during the entire operation unless an emergency condition arises requiring brake power in excess of that offered by the motor brakes, in which case it may be instantly applied by the operator. After the bridge has been closed and traffic has been resumed, this brake will again be applied. This portion of the equipment shall be designed so that it will not be injured if left in release indefinitely. Proper means shall be provided for releasing the brake mechanically when the bridge is to be operated by hand or emergency-power equipment.

189.—The emergency brake motor circuit is to be independent of the general interlocking system, and there shall be a mechanical interlocking device which will prevent the main leaf motors and the emergency brake from being used one against the other.

190.—The emergency brake switch shall be attached to the controller stand within easy reach of the operator and proper labels shall be placed back of the switch handle to indicate "Set" and "Released" positions of the brake.

Current Supply.

191.—Unless the current supply is taken from more than one source, it shall be conducted to the switch-board in two independent conductors, one for the supply, and one for the return current.

Submarine Cables.

192.—Submarine cables, if needed, will be furnished and laid by the Railway Company.

193.—The wiring from the collector rings for the electrical equipment of the bridge shall be furnished by the Contractor.

Qualities of Wire and Insulation.

194.—The quality of all wires and insulation shall conform to the specifications of the Railway Signal Association, as revised and adopted in October, 1911, and contained in Volume 8 of the *Proceedings* of that Association.

Conduits and Minimum Size of Wire.

195.—If wires are to be placed in conduits, the conduits shall be of ample size, sherardized, and loricated on the inside. No wire less than No. 12, B. & S. gauge, shall be used.

Condulets and Factory Ells.

196.—Conduits shall be of sufficient size to allow the wires to be easily drawn in. No joints are to be made inside of a conduit. Condulets and factory ells shall be used. Condulets, ells, and conduits shall be sherardized, and loricated inside.

Wiring, etc., to Conform to Codes.

197.—The wiring, motor installation, and the whole electric equipment must conform to the underwriter's code, and to the city code, if the bridge is subject to city authority.

Fuses.

198.—Enclosed fuses shall be used.

Minimum Stranded Wire.

199.—No wire smaller than No. 10, B. & S. gauge, stranded wire shall be used.

Wires to be Tagged.

200.—Wires when installed shall be permanently tagged and numbered so that any wire can be traced from the switch-board to the motors, and to the source of power.

Ground Connections.

201.—Ground connections of ample area shall be provided.

Quick Brake Switch and Switch-Board.

202.—A switch, of the quick-break type, shall be provided for each supply wire. Each motor circuit and each light, signal, indicator, or other circuit shall be provided with switches which are approved by the Railway Company's Engineer. The switches shall be mounted on an enameled slate panel switch-board (not less than 1¼ in. thick, and free from metallic veins, or flaws) in the operator's house. The switch-board shall be large enough to carry the meters, switches, cut-outs, fuses, etc. Switches, cut-outs, buttons, etc., shall be provided with plates designating their use.

Automatic Circuit Breaker.

203.—An automatic circuit breaker shall be placed on the switch-board in the operating motor circuit of the bridge. Each line to the motor, each line to the electric brakes, and each lighting, signal, indicator, or other circuit, shall be protected by enclosed fuses.

204.—Any circuit whatsoever shall be protected by fuses, circuit breakers, or equivalent devices, which will insure the excessive current being cut off before any parts are damaged.

Lightning Arrester.

205.—The feeders shall be protected by a pole-switch fuse and lightning arrester mounted on a non-combustible and non-absorbent insulating base.

206.—Lightning arresters shall be placed as near as practicable to the parts to be protected, and away from combustible material. A No. 4, B. & S. gauge, wire should be used for the connection; this wire should run in a straight line to a ground plate, and not be connected to any structural parts. To avoid inductive resistances, the wire should not run through a conduit. If a choke-coil is used, it should be thoroughly insulated from the ground and other conductors.

Short Circuiting.

207.—The connections of parts in contact with track shall be such as to allow no short circuiting of track signals.

Protection of Electric Contacts.

208.—Electric contacts shall be protected from the weather or accumulations of dirt.

Housing of Motors.

209.—Motors must be housed in weather-proof metal housing. This housing must be large enough to allow the inspection and oiling of the motor. It must be readily removable so that access to the motor may be obtained. No metal in this housing shall be less than No. 16, U. S. Standard, gauge; it shall be galvanized.

Housing of Solenoids, etc.

210.—Solenoids and electrically-operated brakes shall be housed.

Indicator Lights.

211.—The Contractor shall provide and install electric light indicators for the purpose of showing the operator the various positions of the bridge, especially the fully open, entirely closed, nearly open, and nearly closed positions of the bridge, and the fully open and fully closed positions of the rail lock and bridge locks.

Volt Meter, etc.

212.—A volt meter, ammeter, and watt meter shall be provided on the switch-board. The use of external multiple shunts will not be permitted.

Ground Detector. 213.—The switch-board shall be furnished with one 2-c. p. lamp for detecting ground, and a 2-c. p. lamp for illuminating the ammeter and volt meter scales.

Lamps for Lighting. 214.—In the operator's house shall be placed ten 16-c. p. lights, and additional lights about the machinery and such other lights as the Engineer may direct. For all lights in the house above ten in number, the Railway Company will pay the regular market price or furnish them to the Contractor.

215.—Lights of 16-c. p. shall be placed outside at the head and foot of stairways or similar paths. All lights in the house shall have tungsten filaments.

Channel Lights. 216.—The Contractor shall furnish warning and channel lights and signals, in accordance with the U. S. Government requirements, or other harbor requirements.

Alternating Current Motors. 217.—Alternating motors shall be of the three-phase induction type with slip-rings, rotor-wound, 25 cycles and 220 voltage, unless otherwise specified. The resistances for varying the speed shall be in series with the rotor circuit, and shall be such as to affect evenly all three phases. Motors of 5 h.p. or less may be of the squirrel-cage type.

218.—The methods of testing outlined for the direct-current motors shall apply to the alternating motor.

Control of Motors. 219.—The control of motors shall be electrically interlocked with each other and with the signal system, and the bridge shall be controlled in such a way that the end locks or wedges cannot be released until the signals have gone to the danger position and the derails are set, or the bridge motor started until the end locks and wedges have actually been released. In closing the bridge, the control shall be such as to make it impossible for the operator to move the end locks or wedges until the bridge has been completely closed or to set the signals at safety until the bridge has been closed and the end locks and wedges are in place.

Railway Signal System. 220.—The company will furnish and install the railway signal system, also the master lever and all necessary devices controlling the interlock between this signal system and the bridge as a whole. The Contractor shall furnish and install the necessary devices for interlocking the various' parts of the bridge with each other and for connection to the Company's master lever.

SPECIFICATIONS FOR SPECIAL METALS USED FOR MACHINERY PARTS.

Qualities of Machinery Steel. 221.—Steel for castings may be made by the open-hearth or crucible process.

222.—All castings shall be annealed unless otherwise specified.

223.—Phosphorus	0.05% maximum.
Sulphur	0.05% maximum.

224.—Minimum physical qualities, as determined on a standard test specimen, of ½ in. diameter and 2 in. gauged length:

Tensile strength, in pounds per square inch......	70 000
Elongation: percentage in 2 in.................	18
Contraction of area: percentage...............	25

225.—A test to destruction may be substituted for the tensile test, in the case of small or unimportant castings, by selecting three castings from a lot. This test shall show the material to be ductile, free from injurious defects, and suitable for the purpose intended. A lot shall consist of all castings from the same melt or blow, annealed in the same furnace charge.

Flaws in Castings.

226.—Castings shall be true to pattern, free from blemishes, flaws, or shrinkage cracks. When the bearing surface of any steel casting is finished there shall be no blow-holes visible, exceeding 1 in. in any direction, nor exceeding ½ sq. in. in area. The length of blow-holes cut by any straight line laid in any direction shall never exceed 1 in. in any 1 ft.

Blow-Holes in Gear Wheels.

227.—No blow-hole exceeding one-half the above dimension and area will be allowed in any gear tooth, or in the rim at the root of the teeth.

Electric Welding.

228.—The correction of defects in castings, by welding electrically by thermit or by similar processes, will not be allowed.

Testing of Large Castings.

229.—Large castings shall be suspended and hammered all over. No cracks, flaws, defects, or weakness shall appear after such treatment.

230.—A specimen (1 in. by ½ in.) shall bend, cold, around a diameter of 1 in., through an angle of 90°, without fracture on the outside of the bent portion.

231.—The number of standard test specimens shall depend on the character and importance of the castings. A test piece shall be cut, cold, from a coupon to be moulded and cast on some portion of one or more castings from each melt or blow, or from the sink-heads (in case heads of sufficient size are used). The coupon or sink-head must receive the same treatment as the casting or castings, before the specimen is cut out, and before the coupon or sink-head is removed from the casting.

232.—Turnings from the tensile specimen, or drillings from the bending specimen, or drillings from the small test ingot, if preferred by the inspector, shall be used to determine whether or not the steel is within the limits in phosphorus and sulphur specified in Paragraph 223 concerning chemical properties.

Steel Forgings.

Qualities of Steel Forgings.

233.—Steel forgings may be made by the open-hearth or crucible process.

234.—Phosphorus	0.04%	maximum.
Sulphur	0.05%	maximum.

235.—Minimum physical properties as determined on a standard turned test specimen of ½ in. diameter and 2 in. gauged length:

Tensile strength, in pounds per square inch,	55 000 to 65 000
Elongation: percentage in 2 in.	28

236.—A specimen (1 in. by ½ in.) shall bend, cold, 180°, around a diameter of ½ in., without fracture on the outside of the bent portion. The bending may be effected by pressure or by blows.

237.—The number and location of the test specimens to be taken from a melt, blow, or forging shall depend on their character and importance, and, therefore, must be regulated by individual cases. The test specimen shall be cut, cold, from the forging, or full-sized prolongation of the same, parallel to the axis of the forging and half way between the center and the outside; the specimens shall be longitudinal, *i. e.,* the length of the specimen shall correspond with the direction in which the metal is most drawn out or worked. When forgings have large ends or collars, the test specimens shall be taken from a prolongation of the same diameter or section as that of the forging back of the large end or collar. In the case of hollow shafting, either forged or bored, the specimen shall be taken within the finished section prolonged, half way between the inner and outer surfaces of the wall of the forging.

238.—Turnings from the tensile specimen, or drillings from the bending specimen, or drillings from the small test ingot, if preferred by the inspector, shall be used to determine whether or not the steel is within the limits in chemical composition specified in Paragraph 234.

239.—Forgings shall be free from cracks, flaws, seams, or other injurious imperfections, and shall conform to the dimensions shown on the drawings furnished by the purchaser, and shall be made and finished in a workmanlike manner.

240.—All forgings shall be annealed.

Axle Steel.

Qualities of Axle Steel.

241.—Axle steel may be made by the open-hearth or crucible process.

242.—Phosphorus	0.05% maximum.
Sulphur	0.05% maximum.

243.—Minimum physical properties, as determined on a standard turned test specimen of ½ in. diameter and 2 in. gauged length:

Tensile strength, in pounds per square inch	80 000
Elongation: percentage in 2 in.	20

244.—A specimen (1 in. by ½ in.) shall bend, cold, 180°, around a diameter of 1½ in., without fracture on the outside of the bent portion. The bending tests may be made by pressure or by blows.

245.—Turnings from the tensile test specimen, or drillings from the small test ingot, if preferred by the inspector, shall be used to determine whether the melt is within the limits in chemical composition specified in Paragraph 242.

Boiler Plates.

Qualities of Boiler Plate Steel.

246.—The steel used for boilers and fire-boxes shall be made by the open-hearth process.

247.—Phosphorus .... 0.04% maximum.
Sulphur .... 0.04% maximum.

248.—The physical properties required shall be as follows:

Tensile strength desired, in pounds per square inch, 60 000.

Elongation : minimum percentage in 8 in. $= \dfrac{1\ 500\ 000}{\text{Ultimate strength.}}$

Character of fracture........................ Silky.
Cold bends, without fracture.................. 180° flat.

249.—The ultimate strength shall come within 4 000 lb. of that desired.

250.—Chemical determinations of the percentage of carbon, phosphorus, sulphur, and manganese, shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the Engineer or his inspector. A check analysis shall be made from the finished material, if called for by the purchaser, in which case an excess of 25% above the required limits will be allowed.

251.—Specimens for tensile and bending tests for plates shall be made by cutting coupons from the finished product, which shall have both faces rolled, and both edges milled to the usual form of the standard test specimen, $1\frac{1}{2}$ in. wide on a gauged length of at least 9 in.; or with both edges parallel.

Nickel Steel for Machine Parts.

Qualities of Nickel Steel.

252.—Nickel steel shall be made by the open-hearth process.

	Plates, shapes and bars.	Rivets.
253.—Phosphorus shall not exceed............	0.04%	0.04%
Sulphur " " "	0.05%	0.04%
Nickel, not less than..................	3.00%	3.25%

254.—The physical properties required shall be as follows:

	Plates, shapes, bars, and forgings, pounds per square inch. Minimum.	Rivets.
Tensile strength.......	80 000	60 000 to 70 000
Elastic limit..........	50 000	40 000 minimum

Elongation, percentage in 8 in., for plates, shapes, bars, and forgings; and also for rivets $= \frac{1\,600\,000}{\text{Ultimate strength}} =$ minimum.

Elongation, percentage in 2 in., for forgings = 25.

255.—Specimens cut from forgings (1 in. by ½ in.) shall bend, cold, 180°, around a diameter of 1 in., without fracture on the outside of the bent portion.

256.—Specimens cut from plates, shapes, and bars shall bend, cold, 180°, around a diameter of three times their thickness, without fracture on the outside of the bent portion.

257.—Each rivet rod shall bend 180°, flat, on itself, without fracture on the outside of the bent portion.

258.—Rivet rods shall be tested as rolled.

259.—The fracture of all tension tests shall show a fine silky texture, of a uniform bluish gray or dove color, free from black or brilliant specks, and shall show no sign of crystallization.

260.—All nickel-steel forgings shall be properly annealed.

261.—Annealed eye-bars and similar members, when full-sized pieces are tested, shall comply with the following requirements:

Minimum ultimate tensile strength, in pounds per square inch	75 000
Minimum elastic limit, in pounds per square inch	45 000
Minimum elongation in 10 ft., including fracture	12%

The fracture shall be mostly silky, and free from crystals.

Full-sized pieces shall bend, cold, 180°, around a diameter of twice their thickness, without fracture.

Tool Steel.

Qualities of Tool Steel.

262.—This steel is generally used for parts which require hardening or oil tempering, such as pivots, friction rollers, ball-bearings, and springs.

263.—Tool steel shall be made by the open-hearth or crucible process.

264.—Carbon	1.00%	minimum.
Phosphorus	0.04%	maximum.
Sulphur	0.04%	"
Manganese	0.50%	"

Phosphor-Bronze.

Qualities of Phosphor-Bronze.

265.—Special phosphor-bronze shall be used for high pressures and slow speed.

266.—The metal shall have a minimum elastic limit in compression of 27 000 lb. per sq. in. The permanent set at 100 000 shall not exceed $\frac{1}{10}$ in.

267.—A test piece shall be cut from a coupon to be moulded and cast on some portion of each casting. Test pieces shall be 1-in. cubes, finished.

268.—Phosphor-bronze composed of the following ingredients and of the following proportions has given satisfactory results:

Copper	79.7	per cent.
Tin	10.	“ “
Lead	9.5	“ “
Phosphorus	0.8	“ “

Babbitt Metal.

Qualities of Babbitt Metal.

269.—Babbitt metal composed of the following ingredients and of the following proportions has given satisfactory results and a low coefficient of friction (0.03 to 0.04):

Copper	3.6	per cent.
Tin	89.3	“ “
Antimony	7.1	“ “

Purpose of the Specifications.

270.—It is the purpose of these specifications to provide a first-class structure. They are intended as an aid in designing and fabrication. The subject of machine design is so great and varied that no single work of this character can cover all points. As a further aid in securing a first-class structure, the following works will be considered authoritative in the order named:

1. Unwin's Machine Design, Part I, Ed. 1909.
   Unwin's Machine Design, Part II, Ed. 1902.
2. A Manual of Machine Design, etc., by Low and Bevis, 11th Impression.
3. Reuleaux's Constructor, Translated by Suplee.
4. Kent's Pocket Book, 8th Ed.

271.—Machine parts shall be designed, if practicable, by the methods of applied mechanics, but such designs shall be viewed in the light of experience. It should be borne in mind that machine design is not based on the precise methods in vogue for statical structures.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

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THEORY OF REINFORCED CONCRETE JOISTS.*

By John L. Hall, M. Am. Soc. C. E.

In computing the strength of reinforced concrete floor slabs, it is usual to disregard the tensile resistance of the concrete. That portion of the concrete on the tensile side of the neutral plane is considered only useful for covering the steel, for helping to resist shear, and for forming a ceiling. A small part of this concrete would ordinarily be sufficient to cover the steel and furnish the necessary resistance to shear. The remainder is a heavy and somewhat expensive material for a ceiling. Particularly is this true in the case of long spans which require thick slabs.

By keeping the reinforced steel in large units, a series of parallel concrete joists may be formed, instead of a flat slab. With a thin slab over the top, lightly reinforced transversely, the joists become a system of small T-beams. The expensive form work of such a system is one objection to it, and the preference for a flat ceiling is another. To obviate these objections, burned clay hollow tile with plaster ceiling, or sheet-metal tile with metal lath and plaster ceiling, has been used.

The purpose of this paper is not to discuss the relative merit or economy of these several methods of construction, but rather to discuss the things which should be considered in computing the strength of such a system of joists. Various claims are made as to the work performed by clay tile in combination with concrete joists. It is not

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*This paper will not be presented at any meeting, but written communications on the subject are invited for publication with it in *Transactions*.

the intention to discuss this matter at present. The spaces between joists, therefore, will be assumed to be voids. Fig. 1 shows how such a system was used in a recent design. Fig. 2 is a section through the joists, and Fig. 3 is a section through the beams. Fig. 4, illustrating the mode of bending in a beam with fixed ends, is introduced for the purpose of reference in what follows.

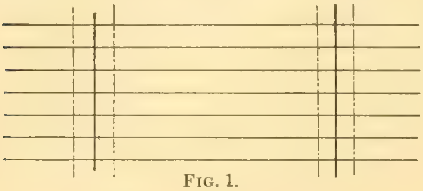

FIG. 1.

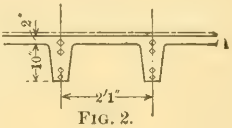

FIG. 2.

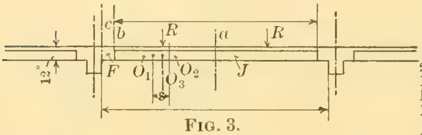

FIG. 3.

21'8" Span
Moment at a (Fig. 3) = 4540 ft.-lb.
Reaction R = 1640 lb.
Moment at b = −7900 ft.-lb.
" " c = −11000 " "
23'10" Span
Moment at a = 5400 ft.-lb.
Reaction R = 1790 lbs.
Moment at b = −9100 ft.-lb.
" " c = −13700 " "

Round Rods are indicated thus (ϕ)
Square, Cold-twisted Bars are indicated thus (⧫)

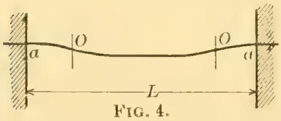

FIG. 4.

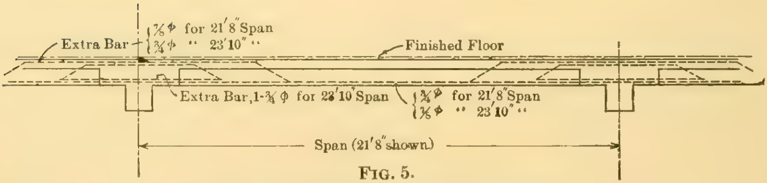

FIG. 5.
TYPICAL DETAIL OF FLOOR JOIST

The bending moment of a simple beam resting freely on end supports is determined solely by the amount and distribution of the load (including the weight of the beam itself), entirely regardless of its sectional shape or materials.

In a continuous beam, however, the bending moment depends on the amount and distribution of loads and also on the elastic curve or deflection of the beam. The elastic curve is influenced by the shape and composition of the beam. What the actual bending moments are in reinforced concrete, therefore, is not known. It is a matter of much difference of opinion among engineers, as shown by the discussion before this Society following the Progress Report of the Special Committee on Concrete and Reinforced Concrete.

As commonly given in books on mechanics, the bending moments and reactions for continuous beams are calculated for the ideal case of homogeneous beams of uniform sections resting freely on level supports evenly spaced. Such cases do not occur in building construction. After many tests of actual construction, the formulas given in the building laws, although based on the ideal case, are recognized as safe, and are in general use; yet it is well to remember always that these formulas are only approximations. The nearer a design approaches the ideal case referred to, the more nearly do the formulas approach the truth. Any material deviation in design from the ordinary approximation to the ideal condition presents a case for special study and determination.

It is thought that the laws of deflection and the amount of deflection under working loads are much the same in reinforced and in plain concrete. Certainly, the small deflections in reinforced concrete, as compared with those in structural steel, show that in the former the concrete is more of a controlling factor in deflections than the steel. This theory is consistent also with calculated deflections using the moment of inertia of sections containing usual percentages of steel. It would seem, therefore, that the reinforced steel has very little influence on the elastic curve of the kind of construction under investigation, except in so far as it prevents tensional rupture and thereby permits higher stresses. In this view of the subject it is apparent that the reinforcing steel should be placed so as to resist rupture where it would be most likely to occur in the concrete.

Looking at the floor construction of Figs. 1, 2, and 3, if it be assumed that this construction is essentially a continuous flat slab, and that the maximum bending moment is at the center line of supporting beams, then the maximum stress both in compression and tension will be along this center line, and the stresses will diminish, according to some law, to zero at the line of contraflexure. Suppose, now, that a large part of the concrete on the compression side of the slab be removed at some place between the center line of the supporting beam and the line of contraflexure; a plane of weakness is introduced which may cause failure where the moment is considerably less than the maximum. This is inconsistent with the premises, and shows that the width of the 12-in. flanges of the beams must be considered in calculating the strength of the floor slab so-called.

If it is assumed, however, that the construction consists of a series of joists or small **T**-beams with one or both ends fixed, then the danger section of a joist occurs at a fixed end, where it joins a beam, and the analysis becomes straightforward and consistent. It is thought, therefore, that the joists should be designed for fixed ends, in accordance with actual conditions.

An objection which might be made to this procedure is that the beam flanges, into which the ends of the joists are said to be fixed, are themselves capable of deflection, so that the ends of the joists are inclined slightly instead of level. This deflection at the edge of the flanges, however, must necessarily be very small, being estimated according to the respective moments of inertia, and is only 40% of what it would be at same line if the joist section ran without change to the center of the beams.

The effect of this slight inclination of the supports would be to increase slightly the positive moment at the center of the joists and to reduce slightly the negative moment at the fixed ends. This reduction of negative moment would cause the calculated negative moment to err on the side of safety, and the slightly increased positive center moment would utilize more economically the excess strength provided at the center.

The negative bending moment along the center line of the beams is the sum of the moments of the distributed loads out to the line of contraflexure, and of the concentrated loads along the latter line. Any change in design that tends to move the line of contraflexure away from the supports and toward the center of the span, would tend to increase the negative moment at the center of the supports. It is conceivable, therefore, that the negative moment in the case under discussion might be somewhat more than $\frac{W\,L}{12}$. If so, additional steel should be provided in the top of the slab across the beams.

The formula, $\frac{W\,L}{12}$, expresses the bending moment at either end of a beam of constant section uniformly loaded and having fixed ends. The points of contraflexure, O (Fig. 4), are located $0.211L$ from the ends. The central portion, O-O, may be considered as a simple beam, uniformly loaded. The end portion, a-O, may be considered as a cantilever uniformly loaded from a to O and supporting at O the reaction from O-O. From these conditions the shear and bending moment can be readily computed for any section in the length of the beam.

In similar manner, a continuous beam is restrained by bending moments at the supports. The points of contraflexure, however, from which the moments may be computed, are not located as easily. Their position is affected by the number and the relative length of the spans and by the distribution of the live loads, whether on some or all of the spans, and by other considerations. In order to simplify the computations, the building laws authorize the use of the formula, $\frac{W\,L}{12}$, for interior spans, and, $\frac{W\,L}{10}$, for end spans. This method of calculating is only approximately correct. Its error is usually, although not always, on the side of safety. The formula for interior spans is the same as that for beams with both ends fixed. For end spans, the formula indicates one fixed end and one partly fixed.

When applicable, the theorem of three moments permits the accurate determination of moments and shears for actual conditions; and, if all the conditions are actually considered, it affords a more scientific method of calculation than the approximate formulas previously stated. The building law recognizes the validity of scientific analysis, and caution would seem to require such analysis, if attainable, whenever the design varies materially from ordinary conditions of continuity, as, for example, when the spans are very unequal in length, or when the conditions of constant section and free support are deviated from in any marked degree.

The features of this design, which vary from usual conditions of continuity, are: (1) the massive character of the supporting beams; and (2) the sudden change in section where the joists join the flanges of the beams.

The joists in interior spans were assumed to have fixed ends, and an attempt was made to determine the location of the points of contraflexure. Investigations by F. E. Turneaure, Assoc. M. Am. Soc. C. E., indicate that, within ordinary working stresses and percentages of steel, the elastic curve of a concrete beam is not greatly influenced by the position of the reinforcement. It appears to be desirable, therefore, to ascertain the natural elastic curve of the concrete joists and place the steel where it is needed in conformity thereto.

Two assumptions were tested: (1) That the ends of the joists are fixed at the face of the beam web; (2) that they are fixed at the edge of the beam flanges. The location of the points, O, was calculated for both conditions, on the basis of a constant section.

The position, O_1, Fig. 3, obtained by the first calculation would be correct if the flange, F, were as flexible as the joist, J, while the position, O_2, would be correct if the flange, F, were perfectly rigid. As the flexibility of F is intermediate between these assumptions, the true position, O_3, must lie between O_1 and O_2, and closer to the one derived from that assumption, which is nearer the truth.

A beam of the section, F, it was estimated, would deflect four-tenths as much under a given load and span as one of the section J. It is then more nearly a rigid beam than one of the same flexibility as J. The point, O_3, therefore, lies nearer O_2 and is four-tenths of the way from O_2 toward O_1.

Having fixed the position of the points, O, the remaining calculations are very simple. The typical detail of the joist, Fig. 5, is designed in accordance with the actual conditions as understood, and the necessary resistance is provided. The moments and shears are stated on that figure.

In view of the fact that the moment at the center of the span of a beam with fixed ends is only one-half of $\frac{W\,L}{12}$, it may be asked why this formula is required by law generally for the center of continuous interior spans, and whether such requirement would be justified in the present instance. Analysis of the spans under consideration by the ordinary theory of continuous beams showed that if only one span be fully loaded, the other spans having dead load only, the fully loaded span will have a moment at the center about two-thirds of $\frac{W\,L}{12}$. If the live load on one span only were greatly increased over the dead load, the moment at the center of the span would be increased in a larger ratio; but, in the absence of those conditions, there appears to be nothing gained by increasing the reinforcement at the center of the span.

Again, the theory of continuous beams does not take into account the torsional stiffness of the supporting beams, which, in the present case, is very considerable. Manifestly, the more nearly we approach the ideal condition of fixed end supports for the joists, the less influence will be exerted by conditions outside the particular span considered, so that the probable maximum moment at the center of the span of the joists will always be less than two-thirds of $\frac{W\,L}{12}$, in this particular design.

In the detail herewith submitted, Fig. 6, the reinforcing steel is disposed in accordance with the foregoing statement of theory.

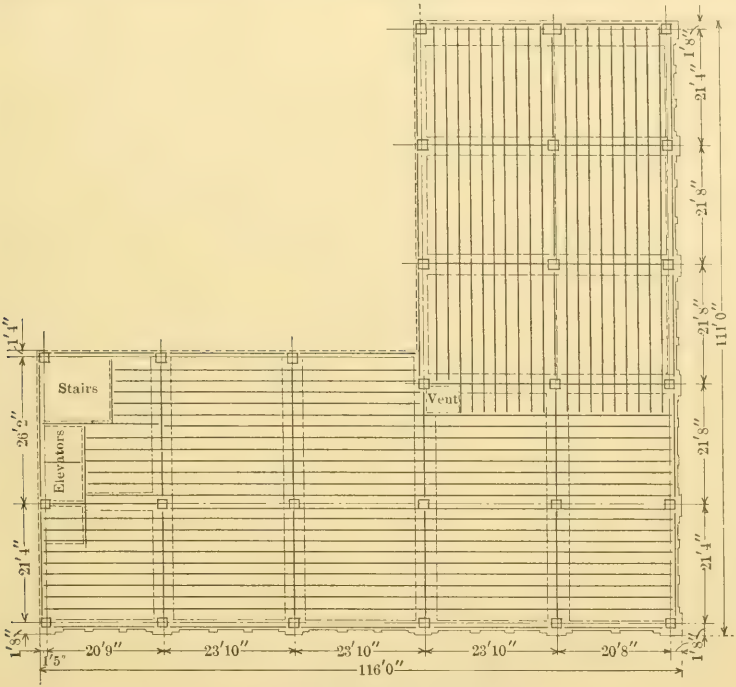

Fig. 6.
TYPICAL FLOOR FRAMING PLAN

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NOTES ON BRIDGEWORK.

Discussion.*

By William P. Parker, M. Am. Soc. C. E.

Mr. Parker.

William P. Parker, M. Am. Soc. C. E. (by letter).—The author's treatment is on the assumption that a continuous beam on three points of support can be dealt with as two separate beams fixed at the middle point and simply supported at the ends.

This assumption is incorrect, as a load on either span affects the reactions on all three supports.

For any load, W (Fig. 4), the sum of the reactions at 1 and 2 is greater than W, while the reaction at 3 is negative. The three reactions, $R_1 + R_2 + R_3$, of course, are equal to W.

The purpose of the investigation seems to be primarily to find the reactions at R_2, the intermediate support, for any load or series of loads. By the method in the paper, the results give a much less reaction than the correct one. The writer, for his work in reinforced concrete design, uses the curves in Fig. 4, which give directly the reaction at all three points of support for a concentrated load in any position and the results from a series of loads can be combined arithmetically to give the resultant reactions. With the reactions found, it is easy to ascertain the bending moment and shear at any point on the beam, and locate points of contraflexure.

Using the notation on Fig. 4: From the theorem of three moments, for any load in the span, 1-2, W produces:

$$\text{Moment } M_1 = 0$$
$$\text{Moment } M_2 = -\tfrac{1}{4}\, wl\,(a - a^3)$$
$$\text{Moment } M_3 = 0$$

Taking the center of moments at the different supports, and expressing the given moment, the algebraic sum of the reaction and loads

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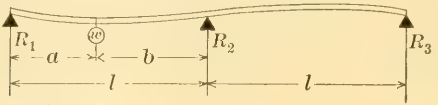
* Continued from August, 1912, *Proceedings*

Mr. Parker.

CONTINUOUS GIRDER OVER 3 POINTS OF SUPPORT



$M_2=-\frac{1}{4}\,wl\,(a-a^3)$

$R_1=+wb-\frac{1}{4}w(a-a^3)$, $R_2=+wb+\frac{1}{2}w\,(a-a^3)$, $R_3=-\frac{1}{4}w(a-a^3)$

Diagram gives reactions at Supports R_1, R_2 & R_3 for a Load "w" at distance "a" from Support R_1. Lower horizontal line represents different values of "a". Where vertical from given value intersects the different curves will give directly % of "w" which goes to each of the Supports.

For check $R_1+R_2+R_3=100\%$

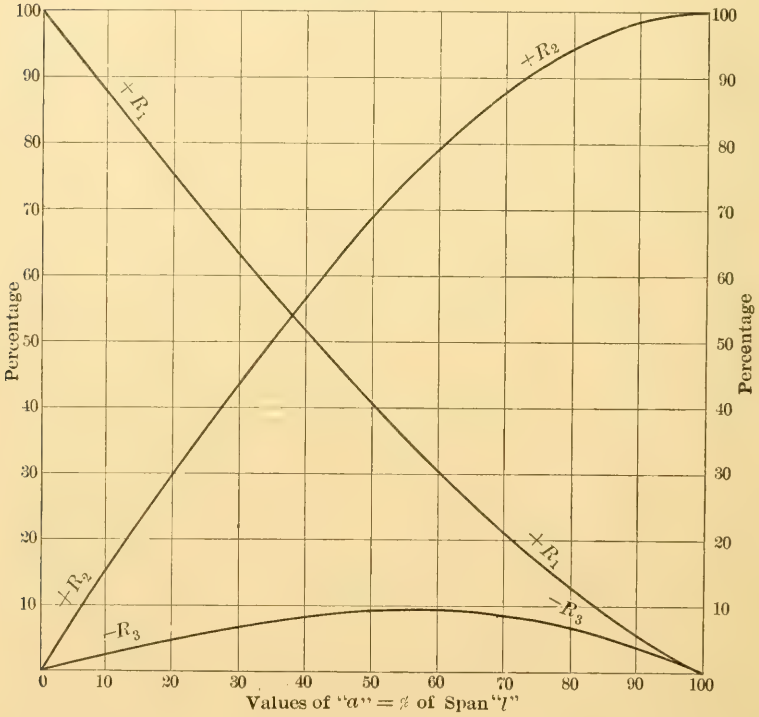


FIG. 4.

Mr. Parker.

multiplied by the arms gives three equations. These, together with the equation, $R_1 + R_2 + R_3 = W$, make it possible to solve for the values of the reaction, as follows:

$$\begin{aligned} R_1 &= + wb - \tfrac{1}{4} w (a - a^3) \\ R_2 &= + wb + \tfrac{1}{2} w (a - a^3) \\ R_3 &= - \tfrac{1}{4} w (a - a^3) \end{aligned}$$

These three equations were used in laying out the curves in Fig. 4.

The results from the use of the curves are readily checked, for, having found the reactions for a given W, $R_1 + R_2 + R_3 = W$.

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THE STRENGTH OF COLUMNS.*

Discussion.*

By Edward Godfrey, M. Am. Soc. C. E.

Edward Godfrey, M. Am. Soc. C. E. (by letter).—This paper is timely and important, not so much because it adds complexity to the already overburdened subject of the theoretical strength of columns, but because it affords an opportunity for a skeptical examination of the basis of all these column formulas, and particularly because any adverse criticism of the basic formulas will no doubt find a worthy champion in the able author. Mr. Godfrey.

In the technical press, the writer has repeatedly assailed both the Gordon-Rankine and the Euler formulas for columns. A paper on this subject, which if not denied ought to have revolutionized the subject, he had difficulty in finding a publisher to accept. It was not controverted when published, and it has not revolutionized the subject; the writer expected nothing of the sort; "what ought to be" and "what is" are separate and distinct things. It takes many years to pry accepted standards loose from a body of professional men, even though these standards are clearly proven false. In the meantime the writer has observed and demonstrated in his practice and reading that confidence in the Euler and Gordon-Rankine formulas has resulted in failure, as the error is so great.

When the writer was a student he swallowed the arguments of his textbooks largely because of the authority behind them. Since he has "put away childish things" he appreciates the fact that the highest authorities may err, and that error may be in the very subject that they know best. He accepted the apparent logic of the derivation of these formulas in those days, just as he would now probably accept what the textbooks state regarding the supposed strength of presumably

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*This discussion (of the paper by W. E. Lilly, Esq., published in August, 1912, *Proceedings*, but not presented at any meeting), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Godfrey. reinforced concrete columns, which are constantly proving, by failing under a fraction of that strength, that such textbooks are wrong. Now, in reviewing his textbooks, he fails to discover any logical basis for either the Euler or the Gordon-Rankine formulas. If there is such basis, it is not stated in these books.

Textbooks say of the Euler load that "under this load the column just begins to deflect, and will under a constant load retain any deflection which may be given to it, within the elastic limit of the material." The writer can find no logical proof of this in the derivation of the Euler formula in these same books. It happens that the Euler load is one that will double any initial bow in a column. If an end load adds 100% to the initial bow of a round-ended column (more properly, one with knife-edge bearings), it will, by reason of this added bow, add another like amount because of that added deflection, and again another and another, and so on *ad infinitum,* or until the column fails. So that, whatever initial bow the column has to start with, it will fail at the Euler load. A column may be perfectly straight, that is, have an initial bow of infinitesimal amount: it will fail at the Euler load, and will not carry any more load than at its first measurable deflection. A similar column may have an initial bow of, say, $\frac{1}{8}$ in.; it will continue to deflect, but will not fail until the load is twice that which gives a total deflection of $\frac{1}{4}$ in. Both columns will sustain the same ultimate load (assuming that they are slender columns), though the originally imperfect one will deflect much more before reaching its ultimate capacity. These facts can be proven by the theory of flexure. They show one of the anomalies of the theory of columns. The writer believes that one would have to search through engineering literature a long time before he would find any statement of these facts, and yet they have a tremendously important bearing on the subject of the strength of columns.

The Euler load is independent of the tensile or compressive strength of the steel, depending only on the modulus of elasticity, which is practically the same for all grades of steel. The Euler load is the absolute maximum that any column can take, no matter how high the elastic limit or the ultimate strength of the steel may be, and two slender columns, of the hardest and of the softest steel, respectively, will have practically the same ultimate strength. These are also anomalies, and are very difficult to find in engineering literature. They also have an important bearing on the subject of the strength of columns.

While the Euler load is the greatest that any column could take, it has practical application only to slender columns. Short columns, by reason of the limiting compressive strength of the metal, cannot sustain loads approaching the Euler load, but will fail by crushing or

Mr. Godfrey.

buckling. Hence some other formula must be used for shorter columns. None can be correct, however, that shows greater ultimate strength for any column than that shown by the Euler formula, and herein is where the Gordon-Rankine formula is in error, at least, in its application in American books. Rankine does not point out this limitation in his derivation of the formula.* His statement: "The greatest deflection [of a rectangular column] consistent with safety is directly as the square of the length, and inversely as the thickness," is not sufficiently full. The deflection which counts is not the initial bow, which might be conceded to be constant for similar columns, but the resulting bow after the load is applied and equilibrium is established. There is no relation between this deflection and the dimensions of the column, for it is a function of the load itself. Any treatment that fails to recognize this is incomplete and is likely to result in error.

Dr. Lilly, in effect, ties up his Gordon-Rankine formula with the Euler formula when he recognizes that the deflection or curvature in the column will limit its carrying capacity. His values of p cannot exceed the Euler unit stress. The constant of his Gordon-Rankine formula is thus deduced from purely theoretical reasoning. This is eminently better than empirical determination of the constant as the latter has worked out.

A common value for the constant of the Gordon-Rankine formula for round-ended columns is $\frac{1}{18\,000}$. This, with a value of 50 000 for f, gives, for the ultimate strength of a column having a ratio of slenderness of 240, a unit stress of 11 910 lb. per sq. in. (Handbooks work this out for the busy user.) The Euler load for this column is only 5 140 lb. per sq. in. This is the absolute maximum load that any column could take, and yet a formula in general use appears to show that it can take 132% more than this. Here is the count which the writer would urge against the Gordon-Rankine formula, and he has known failure to result from confidence in this same formula with the constants commonly used.

The writer believes that the Gordon-Rankine formula fails to meet the needs of the practical design of columns, and that a straight-line formula is far superior. It gives results closer to those obtained from experiments, and there are several reasons why it should.

Columns, as commercially manufactured, are imperfect, of necessity, and a formula for their design should take into account this fact. They are not in true alignment, and their end connections are not always central. The writer has shown† that, if proportionate

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* "Applied Mechanics," p. 361.

† *Railway Age Gazette*, July 2d, 1909.

Mr. Godfrey. imperfections are assumed in columns, a purely theoretical formula can be deduced, which, though very complex, gives a locus which is almost straight for a large part of its length and agrees closely with the commonly used straight-line column formulas.

The ultimate strengths of test columns fall away rapidly after the range of very short columns is passed. This is probably because of local crimping or buckling of the metal, but it is a fact which must be dealt with in the treatment of columns. The Gordon-Rankine curve does not take this shape, hence it fails to meet this condition. The straight-line formula does meet this condition, for the locus falls away from the start.

The straight-line formula has the further advantage that it discourages the use of slender columns. Slender compression members may be weak by reason of their own weight, or, if in a vertical position, an accidental blow may cause them to fail.

In the writer's opinion the whole subject of columns in engineering textbooks should be re-written, and its theoretical treatment simplified, instead of being rendered more complex. A large part of the engineering literature on this subject could be expunged with resulting benefit.

It is manifestly impossible to evolve a formula which will show close agreement with any comprehensive series of tests, for the reason that similar columns show discordant results. The exact strength of structural steel columns cannot be predicted, because imperfections of manufacture enter so largely in the results. Approximate results are all that can be expected, and simple theory answers this purpose just as well as the most complex theory ever devised.

In this re-casting of column literature, the importance of the Euler load should be emphasized, not as a load which the column can hold in equilibrium, conveying the idea that there is surplus strength in the column, but as the extreme limit of its carrying capacity.

Another fact of great importance which should be emphasized is that slender columns of all grades of steel are of practically equal strength. Working formulas should recognize this, and values should converge for long columns in low and high steels. Nickel steel struts of light dimensions are not economical, because their strength is practically the same as for soft steel, though they cost much more.

The converging of the strengths of columns of different grades of steel as the lengths increase has been illustrated by some tests* made by J. A. L. Waddell, M. Am. Soc. C. E. With similar columns of carbon steel and nickel steel in which $\frac{l}{r}$ was 27, the average strength

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* *Transactions*, Am. Soc. C. E., Vol. LXIII, p. 250.

Mr. Godfrey.

of the latter was 75% greater than that of the former; with others, in which $\frac{l}{r}$ was 81, the nickel steel columns averaged only 47% stronger. This indicates clearly the convergence to equality that theory proves must exist in slender columns of high and low steel.

On the Continent of Europe the Euler formula seems to be the standard for the design of columns. This is a grave error which American engineers do not commit. The Euler formula has no application whatever to columns of ordinary lengths, as used in bridges and buildings, for the values increase as short lengths are approached, and it would require steel of almost unlimited strength to satisfy the formula and hold up under the compression.

A short time ago, a gas-holder post, in a structure in Germany, failed, with disastrous results. The column was designed by the Euler formula, which was one of the errors made by the designers, for it was not (as considered by them) a slender column. The gravest error made in the design was the use of batten-plates instead of lattice. Another woful lack in the theoretical treatment of columns is that of emphasis on the extreme importance of some means of carrying shear in both rectangular directions in the column. Batten-plates will not do this in any adequate degree. This column was made up of two 5-in. channels held together by a few pairs of small tie-plates. As the writer has pointed out,* these tie-plates, or batten-plates, cannot prevent the channels from bowing and acting practically as separate slender columns. Fig. 5 shows this column and how and why it could fail as a slender column. It is surprising that a high European authority, instead of condemning this flimsy construction, on the basis of common sense and theory, delivered the following:

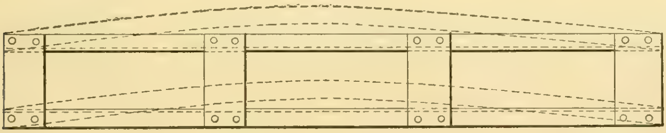

FIG. 5.

> "The use of tie-plated columns, when the section is assumed to be integral, may lead to constructions which do not afford adequate security under loading of unusual character."

Much is said of the impracticability of securing true hinged or pin ends on columns in testing them, and the idea is prevalent that most compression members are in fact practically fixed-ended in structures. This is more of the misinformation of engineering literature. It is much easier to get a practically pin-ended member in a

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* *Engineering News*, July 27th, and September 28th, 1911.

Mr. Godfrey. structure than in a testing machine. In the latter, the rigid heads and friction on the pins hold the member under test almost rigid at the ends. In a bridge, the compression members are only insecurely held by other members as weak as, or weaker than, themselves.

A case which came under the writer's notice is that of the strut of a jib crane shown in Fig. 6. The designer considered this as fixed-ended, and proportioned it by the Gordon-Rankine formula. It is no wonder that failure occurred. The writer considered the strut as of the slenderness of one of the channels, and pin-ended. This is the only reasonable way to treat it. It could fail by the bowing of the two channels, as indicated. The single pair of batten-plates could offer but little resistance. The gusset-plates, to which the ends are attached, are more nearly like ideal pin-ended connections than pins would be, for there is practically no resistance against rotation.

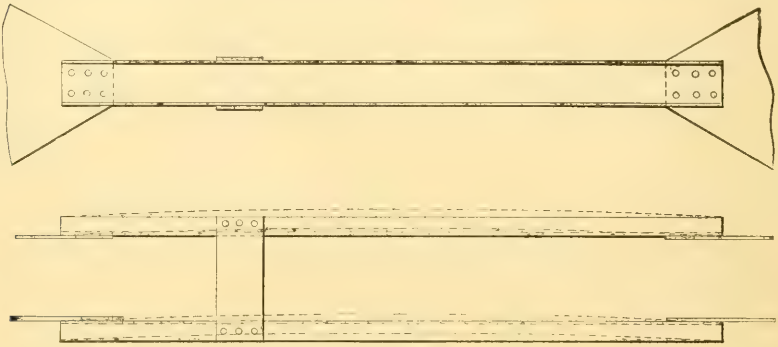

Fig. 6.

These are some of the things that could be written into the subject of columns to replace a vast amount of meaningless mathematics.

The subject of reinforced concrete columns has sprung up with a rank growth of mathematical nonsense which every great reinforced concrete disaster disproves. Tests are interpreted as applying to construction, while they do not embody the essential features necessary to safe construction. Columns utterly lacking in toughness are tested with infinite care (in testing) in order to preserve their evanescent strength; then such columns are built into a structure where toughness is an essential characteristic. Is it any wonder that the Engineering Profession is degraded by periodic wrecks, when its leaders show such lack of common sense?

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STREET SPRINKLING IN ST. PAUL, MINN.

Discussion.*

By S. Whinery, M. Am. Soc. C. E.

S. Whinery, M. Am. Soc. C. E. (by letter).—This paper is so interesting and valuable that the reader reaches its end hungry for more information. Mr. Whinery.

It is so seldom that this branch of municipal work receives, from city engineers and city officials, anything like the attention it deserves or that is given to other departments of city work of no greater importance, that any one who takes an interest in the matter must welcome this account of an intelligent and efficient organization for street sprinkling in St. Paul. It is sincerely to be hoped that the author will favor the Society with another paper dealing with experiences and results. It would be very interesting to know about the practical working of the system, the efficiency attained, as compared with the usual unsatisfactory organization—or lack of organization—and the degree in which the service is successful in abating the dust nuisance and in meeting the reasonable demands of the public.

Particularly would engineers be glad to know the detailed cost of the service, reduced to units readily comparable with results in other cities.

The writer would suggest, as the most simple and satisfactory unit of quantity, 1 000 sq. yd. of street sprinkled once, and that all other elements of cost and service be based on this unit. The units commonly used (where statistics are reported at all) are often so indefinite or general as to be of little use for comparison. Thus, the number of miles of street sprinkled through the season is of little

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* This discussion (of the paper by C. L. Annan, M. Am. Soc. C. E., published in *Proceedings* for May, 1912, and presented at the meeting of September 18th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Whinery. value unless one knows the widths of the streets and the number of times they are sprinkled daily, or rather the number of times they are sprinkled during the season.

The method described for assessing the cost of the service on abutting property owners seems to indicate that the width of the street is not taken into consideration. It seems proper that this should be done. Those owning property on a wide street certainly receive more service than those on a narrow street; and as property on a wide street is usually more valuable than that on a narrow street, the owners might justly be required to pay in the ratio of the work done, that is, the area of the street. To provide for this, of course, would introduce another factor into the computation of the assessments, but if the widths (or half widths) of the streets are known, the actual work of computation would not be increased greatly, though the unit on which the assessment is based would be changed from front feet to square feet, or square yards.

It is not stated how street intersections are dealt with in assessing the cost, though the inference that the cost of sprinkling intersections is taxed on the property owners seems to be warranted; nor is it stated how corner lots, sprinkled on two sides, are assessed.

As it is stated that street oiling is used to some extent, it would be interesting to know the relative cost, efficiency, and general merits of oiling and sprinkling in St. Paul.

It is not only in St. Paul that stand-pipes for supplying sprinkling wagons are regarded as nuisances. Their unsightliness might be overcome in most locations by using a valve and connection placed under the edge of the sidewalk and covered by a hinged plate. The chief source of dissatisfaction is usually the "sloppiness" around these stand-pipes. This is chargeable largely to the carelessness of drivers in allowing the tanks to overflow, and, where the hose is permanently connected to the tank, in allowing the water contained in it to waste on the street after it is disconnected. In this form of connection the trouble would be largely overcome if a valve were placed at the rear end of the hose, and closed before the hose is disconnected from the hydrant. Certainly this trouble can be overcome by the use of appropriate devices and reasonable care on the part of the driver.

While in most cities the municipality supplies, free of charge, the water used for sprinkling, and its value is not charged to the account, it is very desirable that the approximate quantity and cost should be reported, in order that a complete statement of cost per unit area may be deduced.

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ENGINEERING EDUCATION IN ITS RELATION TO TRAINING FOR ENGINEERING WORK.

Discussion.*

By Messrs. Alexis Saurbrey, J. X. Cohen, George F. Swain, William J. Boucher, Almon H. Fuller, Walter Hinds Allen, C. H. Stengel, Charles Warren Hunt, Arthur H. Blanchard, Philip W. Henry, John C. L. Rogge, Charles H. Higgins, Charles B. Buerger, and Ernest McCullough.†

Mr. Saurbrey.

Alexis Saurbrey, Assoc. M. Am. Soc. C. E. (by letter).—It is very important to distinguish between "Engineering Education" and "Engineering Training." As to the first, education is, or should be, the common property of all civilized men, and the engineering school should not waste its time on the hopeless task of instilling true education, where home, environment, associates, and natural disposition have failed. Schools, colleges, and universities are struggling in vain when they attempt to "teach" taste, good manners, and gentlemanly behavior, if these qualities are not planted in the average boy at home, or, in many cases, acquired by less happy boys through natural disposition. "The well-read man is generally able to pose as a 'cultured' man," Mr. McCullough will have us believe. The writer denies this proposition, as well as the desirability of teaching young engineers to "pose." Certainly, it is a pleasure to meet a cultured, well-balanced, considerate man, and we cannot have too many engineers of that kind; but if an engineer is not so well-equipped, let him by all means avoid the deceit and shame of "posing."

The writer, therefore, thinks that the sole problem of the college is to train. It cannot hope to train for the exceptional position at

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* Continued from August, 1912, *Proceedings*.

† Author's closure.

Mr. Saurbrey.

the top of the Profession, but it can, and should, train for usefulness in the common, average case. The young engineer leaving college should be able to do correctly what Mr. McCullough properly refers to as the clerical work of engineering: Compute quantities, calculate stresses and strains, use the level, tape, and transit, and so forth. When, as a matter of fact, he cannot do that, the colleges are not solely to blame, for the preparatory school should have taught precision in algebra and arithmetic, which it does not do. Any really efficient reform movement in engineering education must begin with the home, and must fully consider the public school. With this attended to, the college will automatically adjust itself, and produce better engineers from the better raw material.

Nevertheless, some of the criticisms of the colleges are justified. No doubt the very broad training leads to neglect of details, and to superficial study. The remedy lies in an extension of the time for the purely engineering training, and in a curtailment of the volume taught, especially a reduction in the introductory studies of the first two years, whereby more time might be gained for the real engineering subjects. Such items as chemistry, physics, descriptive geometry, geology, and higher mathematics might, profitably, be reduced in volume, with the proviso that the subjects taught be really and thoroughly assimilated by the student, especially the simpler problems in analytic geometry and calculus.

The course in civil engineering, properly speaking, should certainly not be less than 2½ years (better 3 years), after the completion of the introductory studies referred to. All this time should be devoted to a most thorough drilling in fundamentals, with very little attention to generalities. The use of mathematics should be reduced to an absolute minimum, all complications being carefully avoided; understanding should be the goal aimed at, that is, intelligent application of thoroughly understood principles. Only a very few branches of civil engineering are on a truly scientific basis, and this fact might be taken advantage of, and engineering taught rather as an empirical profession than as a science; in other words, do not bother too much with the mathematical proofs of propositions which are, in reality, proved only by experience and experiment. The impossibility of transmitting telegrams across the Atlantic, the impossibility of flying, have been proved time and again mathematically, and yet the possibility was proved the next day in practice.

Without doubt, many teachers are trying to do just what is suggested here, and, if so, the writer feels that they are on the right track, and wishes that they would go still further. Many colleges, also, during the last few years, have given additional attention to the commer-

Mr. Saurbrey.

cial side of the question, and correctly so. While the writer certainly would be the last to excuse rank commercialism in anybody, he recognizes the fact that the engineer's principal purpose as an engineer is that of increasing values with as little expenditure as possible. The engineer is a wheel in a great commercial machine; as soon as he emerges from the modest initial incubator stage, he deals almost exclusively with business men; and the one question he has to answer is "what does it cost?" If, in addition, he cannot show that he himself is a fairly good investment, he will assuredly lose his job to the one who can. As it is, it takes a good while for the young engineer to satisfy himself and others that he is really worth his salary, and that is not right. It will be different when the graduate has been taught the immediately useful facts and formulas, and when he has ability to discriminate between extravagant and economical design of simple structures.

It is not necessary to state that the college should teach its students the rudiments of bookkeeping and cost keeping. Instead, it seems that scientific management has been taken up. If hereby is meant "motion study" and such matters, incalculable damage will be done, for men are not machines, and should not be treated as such. Moreover, the writer believes that this fad will be a thing of the past in a few years, and the college should be very conservative in introducing such matters.

Mr. McCullough's paper, as well as his recent book "Engineering as a Vocation," are most valuable and interesting. They disclose in a clear, concise, and wholly unprejudiced manner the very foundation for that dissatisfaction so common among recent graduates, and so often expressed by them in the engineering press. It is not only a question of pay, for engineers are as well paid as attorneys and doctors, and much better than teachers or ministers, all of whom have to put as much time on their training. It is mainly a question of competency, of ability to render service in the world as it is—the engineer seeing the great opportunity he has for service while the public does not; but the public will. The engineer of to-day is a pioneer who must clear the forest of misunderstanding, indifference, and inertia, and that takes time. In addition, the fields opened by the modern testing machine, indeed, by the modern spirit of research, have not been properly explored, and we still suffer from many "ifs" and "buts" to be solved in the future. The problem of writing good textbooks is no easy one, when new research makes old truth obsolete over night, and, as long as the teacher must study the changes in the fundamental theory, he is greatly handicapped as a teacher. For this very reason, reading knowledge of foreign languages is almost indispensable to an engineer who wishes to be up to date in his specialty; but

Mr. Saurbrey. they should be taught in the preparatory school, and along practical lines, not in the college.

On the surface, the problem raised by Mr. McCullough seems possible of satisfactory solution; but in reality it is one closely connected with the home and the public school, and, therefore, with the community at large. The battle-cry of to-day is reform, the enthusiasm behind the guns is dissatisfaction. One question, indeed, suggests itself strongly: Is not the failure of the weak, and the survival of the fittest, a principle against which we are battling in vain? one that will exist even if the most ideal vocational training were given? Surely those who are now dissatisfied engineers would otherwise be dissatisfied mechanics, and no happier than they are at present.

Mr. Cohen. J. X. Cohen, Jun. Am. Soc. C. E. (by letter).—The author aims in the proper direction. He seeks to serve the student first and then his future employer. The sound, fundamental, non-specialized technical course which the author recommends makes the student broad and receptive, rather than narrow and exclusive.

It is encouraging to note that the course outlined emphasizes so greatly the study and the value of English. By English is not meant the polished literary language of the library, but the sturdy style of the council chamber and the business office. To the great detriment of the engineer, his English course has usually been made a minor one, and very often neglected at that. That is a very serious situation, and calls for rapid remedial measures. Certainly, engineers should first know how to handle materials, but what more valuable materials are there than men, and what means of communication between men exists, other than language? Even when engineers deal with each other directly, what matters it how well their minds may operate if the thoughts cannot be transferred clearly and correctly? We all know men who have good ideas and excellent thoughts which are hardly ever realized, solely because they are not plainly stated. The ultimate significance of the idea cannot be quickly made clear to others, and it dies before it develops.

The author considers that course in engineering most beneficial which permits of alternation between class-room and field, between school and shop. The writer, having received such a training, and having further observed the comparative effects of the older method of training, heartily endorses the newer.

There are several technical high schools in New York City, the graduates of which are equipped for entering either the engineering school for advanced studies or the engineering office for practical work. It may be of interest to state that a very large percentage of these graduates goes immediately into actual work rather than into

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college, without, however, having abandoned the idea of a higher technical education.

Having secured a position which their technical high-school training qualifies them to hold, they next enroll in the evening engineering course of the Cooper Union for the Advancement of Science and Art, or some similar institution, of which there are also several in New York City. Here they spend their evenings for a good many years—five years at Cooper Union—in hard, arduous, and comprehensive study, supplementing the practice followed during the day with the knowledge gained at night.

This method of study makes for the greatest good. The co-ordination of class and field produces results which are harmonious and well-balanced. Studies are pursued with the greatest interest; their immediate application in practice is either actual or plainly discernible, and their utility needs no emphasis by the instructor. Very often the problems arising during the day may be worked out in the laboratory or class-room during the evening. This produces impressions which are vivid and knowledge which is secured. At times the pace in the class-room would appear to the regular day school instructor to be extraordinary. This combination method makes speedy and successful studying possible.

Such a combination course helps a man financially in several ways. For one thing, he is self-supporting throughout all the period of study, despite the fact that such a course may take a longer time than the so-called regular one. He is employed constantly, and not only during school vacations. This surmounting of the financial barrier is valuable to the Profession, for otherwise many good men would find it hard to prepare properly for practice. For another thing, the combined day worker and evening student finds that as his technical knowledge increases his employers correspondingly increase his compensation. As he observes his increasing pay, he notes the effect of his spare-time study on it, and, as a result, the incentive for further and more concentrated study is greatly strengthened. Better than a good report card is a larger pay check, for while the first predestines the other as an eventuality, the second is the actuality. Not all men, especially in engineering, work for gain, but the stimulating and encouraging influence of tangible recognition is highly beneficial. Finally, a man is helped financially—as well as in numerous other ways—by being kept so busy that he finds no time to get into mischief.

The graduate of the combination course, when he receives his degree, is handed a certificate which shows that he has demonstrated his capacity for hard, continuous, single-centered work. If he had not possessed this ability at the beginning of the course, he would never have reached its end, except through the inculcation of that faculty

Mr. Cohen. in him by the example of his fellow-students. If for nothing else, such a course is of value as a demonstration of the true capability of the man to do diligent work and his real capacity for conscientious, continual toil. Too few men realize until very late in life the enormous amount of work that can be accomplished without undue fatigue by strict adherence to a carefully planned programme. Further, the utilization of spare time for self-improvement is taught in an unforgettable manner, and as the graduate must necessarily be a student after graduation, by pursuing the combination course he learns how and when and what to study after his college days are over. The waste of spare time prevalent among many young engineers is great, and it is a waste which is a direct result of the lack of early training in spare-time study. The student of Cooper Union learns to work even when traveling on trains, unconsciously following the example of the most eminent consulting engineers in active practice. He who learns how to utilize all his available time efficiently has a splendid start in the race toward professional success, which ordinarily can only be attained by continual concentrated application; and to this type of application the graduate of the combination course is no longer a stranger.

The student who is engaged simultaneously in the study of engineering and its practice enjoys a great privilege. He can ascertain whether he has that aptitude and inclination for engineering, which, to a great extent, is vital to success long before he has invested much money in his course or much of the even more valuable time in its study. He has the advantage of being able to decide whether engineering appeals to him as a life work at a much earlier stage than the regular school student. The number of students who are graduated from the regular course, and fitted by training for engineers, is now very large, but of these only a fair percentage is fitted for it by natural talent, inclination, and equipment. Many realize this some years after graduation, but then it is too late, from their viewpoint. Having spent so many years in preparation, they fear to see all their efforts go to apparent waste. They also greatly fear the possible ridicule of their friends at their early recognition of and submission to failure in their chosen calling. Such motives as these keep many men in the ranks until, by force of circumstances, they are forced out or forced up. For a long time, however, they encumber the lower rungs of the ladder, making it harder and harder for themselves as their numbers grow, and also more difficult for the young engineer of future merit to obtain a foothold; but whether or not they stay in the Profession, they have suffered a grave economic loss. In this loss the community at large is also a participant, and it is to relieve

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the public and the prospective engineering student from as large a measure as is possible of this partly preventable loss that the combination course is advocated by the writer.

The Profession is benefited directly by the combination course. Few but the strong, the steady, and the persistent complete such a course, so that the process of weeding out starts at once and has just that much longer to operate. It is an effective block to the lazy, unambitious young man, who would stand but a slight chance were he to enter active practice. If time were available, the writer would like to discuss the role of the engineering teacher in the school attended by students who are at the same time in active practice, but suffice it to say that these teachers must be mentally alert, on the very *qui vive* for the latest and best information and methods of its presentation, and altogether on a high plane, in order to maintain the necessary leadership over their students. Otherwise, they will find themselves being taught by their own men, who, in some details, may be better acquainted with the subject. To the Profession, the value of such a high teaching tone need hardly be pointed out. Furthermore, the student working at some branch of engineering, as he nears the end of his course, can decide for himself whether he prefers that particular branch as his future specialty. He can then begin to supplement his training in the engineering fundamentals by a course of study in his chosen specialty. Such an early decision as to the choice of a life work, if made carefully and discriminately, makes available more time for the attainment of that greater knowledge and understanding of a subject which produces the real specialist. Finally, it starts the student under auspices which will operate for his individual betterment and for the benefit of the Profession.

It may be urged that the grind of the combination course leaves the student no time to attend social functions. In a measure this is true, and hence beneficial, as previously pointed out, but it is not altogether true. The writer's experience and observations lead him to believe that all necessary social functions can be attended without hampering seriously the work at office or school. The course is not one grueling grind, for it is interspersed with a number of holidays and a long summer vacation. By careful and far-sighted planning, a time for almost everything that is reasonable can be found. Of course, numerous social activities, which make up a part of the college life and take up an appreciable part of the student's time, are necessarily curtailed or completely eliminated. The advantages to the student of such comparative freedom from the disturbing and, at times, harassing influences of many social engagements need hardly be pointed out. The impression, however, should not be gathered that the combination-course student is a "grind" simply because he

Mr. Cohen. lives the concentrated life demanded in large part by modern industrial conditions. His lot is not a hard one, and, being always busy, he is in general always happy.

Mr. Swain. George F. Swain, M. Am. Soc. C. E.—The speaker is always very glad to read a paper on education by a practicing engineer, and always derives some good from it. This is true of Mr. McCullough's paper, but, at the same time, there are certain points in it with which he does not agree.

Mr. McCullough states that we must distinguish between engineers and engineering teachers. As Professor Constant has pointed out, the majority of engineering teachers at the present time are or have been engineers. Many of them are practicing and teaching at the same time; and, as Professor Constant states, the younger men who take up teaching are drawn generally from the ranks of practicing engineers. These teachers know probably better than any one else how a curriculum should be drawn up, because they know, not only what the practicing engineer wants, but also what it is practicable for the school to do. It is impossible for a man who has not tried to teach to draw up a curriculum which will work well; he almost always forgets that the problem of engineering education, or of education in general, is not an engineering problem, but a human problem. We talk about the teaching of engineering, but we probably forget what we were, or what the ordinary boy is, at eighteen or nineteen, and we cannot very well theorize unless those things are kept in mind.

One of the most important things to remember is this: Mr. McCullough speaks about the engineer drawing up a specification of what he wants in a man, and the schools filling that specification. The speaker does not think that an engineer can draw up a specification of what he wants, and if he can, the schools cannot fill it, or at least they cannot guarantee to fill it, because they can only teach the student what he can do for himself. The teacher does not give the student knowledge, he shows him how to get it; and if the student does not want to accomplish anything himself, the teacher cannot force him to do it.

The manufacturer, who, for instance, wants to make a spoke of a wheel, can take a piece of wood and fashion it into the proper shape. Now, it may be said that the teacher's raw material is the student, and though the teacher knows what he wants to make of him, he cannot control his raw material; he cannot cut away here and add there, he can simply show the student what he can do for himself. The most important thing in teaching, therefore, is not what shall be taught, but how it shall be taught. That is a truism, a platitude, but it is what we must keep in mind. The important thing is to have the proper atmosphere in the school, in order to make the young men

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realize that they have great opportunities before them, and that they are being offered a chance to gain physical, mental, and moral qualities which will fit them to meet the problems of life.

When the employer of engineers asks for an assistant, he does not care very much what the young man knows; that is of the least importance. He wants a man who is faithful, who is of good character, conscientious, who can think straight, who will not be anxious to stop work as soon as the bell rings, who will be loyal to his employer, who has "gumption," and who can meet emergencies. The amount of knowledge he wants in the young man at the start could be given to him in a very short time. It is the other qualities which are important. The school, therefore, should pay particular attention to the cultivation of the proper atmosphere.

The speaker, of course, has his ideas in regard to what engineering schools should be, and they are very simple. The trouble with the schools is that they try to carry their technical instruction too far; they are narrow; they do not realize that the young man, in starting his career, will not need much knowledge, and if he has the little that is needed, and the other qualities which have been mentioned—the ability to think straight and to take up a new subject and master it—he will be ready for his job, and for promotion, whenever the chance comes. The majority of schools, therefore, should pay more attention to fundamental principles, and not try to carry details quite so far in particular branches. There ought to be a few schools for post-graduate instruction for men who are qualified and can take the time for a more thorough education; and with such an arrangement and the proper kind of instruction, engineering schools should be able to turn out men who will be satisfactory to employers.

The engineering schools are turning out good men to-day, but, like everything else, they can be improved. The schools realize this, and each is trying to remedy its defects as far as possible. One trouble is that parents do not co-operate sufficiently with the schools, the prevailing tendency being to throw everything on the latter. Parents should earnestly co-operate with the school in making the students realize the great opportunities offered them, and the fact that they must work hard; this does not mean to work all the time, but to work hard and endeavor to utilize their time to the best advantage.

Mr. McCullough and one of those who discuss his paper refer to the fact that there are numerous instances in which a man finds himself in after life practicing a different branch of his profession from the one he studied in college, the inference seeming to be that this is a very bad thing. The speaker has never been able to consider it so. The main thing is to follow a line of study in college which will give a man the qualities which he needs to enable him to meet the problems of life. The speaker has had engineering

Mr. Swain. students who subsequently became ministers; others who became lawyers; some who became artists; one or two who have become economists; and others who have gone into business. He has talked to many of these men, and has yet to meet one who has regretted his engineering education. They all admit that such a training gave them what was more valuable than anything else, namely, the ability to concentrate, to work hard, and to get results.

In fact, the speaker has almost come to feel that the study of engineering is about the best training for a young man, no matter what his future career is to be; and if he had a son, whether he was going into business, into the law, or into anything else, he would select such a training for him, because he thinks it would give him, better than any other, those powers which he would desire him to acquire. Besides, he would be dealing with every-day things. Engineering is practical, and engineers are dealing continually with electricity and with mechanics. If these views are correct, we should not be surprised to find many men taking courses in civil engineering and afterward practicing as mechanical or electrical engineers, or *vice versa.* There are very few men who, when they enter college, can feel sure that they are fitted for any specific branch of the Profession. They may know that they like engineering, but their future career is very likely to be determined by some trivial accident. If a man has a good training to start with, and the character and the power that he ought to get at school, he will succeed, and he ought not to be the subject of criticism because he takes up some other branch of work.

With reference to the usefulness of modern languages to the engineer, Mr. Boucher and the author think that modern languages ought not to be required in engineering education. In regard to that the speaker disagrees with them entirely. Recently, he attended the Sixth Congress of the International Association for Testing Materials held in New York City. There were several hundred men at that Congress from all over the world, including the most prominent representatives of that branch of the Profession from almost every country of Europe, one from China, and one from Japan. Almost all those men could speak English; most of them could speak two modern languages. Mr. Henry M. Howe, one of the most distinguished of American engineers, the President of the Association, made his address of welcome in six languages, though the speaker does not suppose that he speaks each of these six languages fluently.

Now, if it is believed that the engineer should occupy a high position among men, not merely that he should be able to do his engineering work properly—building his bridge, laying out his road, or designing his power station—but that he should occupy a high position among men, it appears that a knowledge of such things as modern languages should be encouraged. It is, of course, perfectly true that a man can become just as good an engineer, in a purely technical sense, without knowing anything of modern languages, of economics, or of a great many other things, but a very high standard for the Engineering Profession should be demanded and maintained, not simply in engineering, but among cultured men, and if that is done, a knowledge of at least one modern language, and preferably of two, should be encouraged. Therefore, a student who is graduated and takes a degree from an engineering school should have at least a good reading knowledge of one modern language. The man who cannot get that, can take a special course and get through technical instruction, but the colleges and professional men of to-day aim for something broader than mere technical training. Mr. Swain.

William J. Boucher, Assoc. M. Am. Soc. C. E.—This paper is both interesting and timely. Changes have occurred and are occurring in all lines of business, including engineering, and why should not corresponding changes take place in preparation for business and engineering practice. The speaker agrees with the author that schools and professors should aim to fit their graduates more closely for the work to be undertaken immediately after commencement. Very clearly does the speaker remember his first days in engineering work—at the very bottom—and the many very ordinary things he did not know. Mr. Boucher.

The author expresses the belief that engineering schools of the future will require a minimum of six years' work, of which two years will be spent in the preparatory school, but adding two years to the entire time required in preparation for the life work. The speaker believes that such a lengthening of the course would be a mistake. The average age of entering students has increased steadily, due to the increased entrance requirements, until it is now generally about 19 years, which, with a four years' course, makes the graduate 23 years of age; it does seem that this is old enough to start life's practical work, without requiring an additional two years, making him 25 years, or possibly 24 years, if he has been fortunate enough to finish the course in three years. Very few men would be able to do this, for a variety of reasons, chief of which would be the financial one, and those who had their tuition paid by parents or others would hardly feel the stimulus to do it in less than the prescribed time. The speaker was graduated at the age of 21 years from one of the best known mechanical engineering schools, after 14 years of continuous study, and felt and still feels that that was quite late enough to go out into the world. The following advertisement, copied from a recent issue of one of the leading engineering weeklies, appears to emphasize this latter point:

"Position wanted by graduate civil engineer, 25 years, one year's graduate study, open for permanent position in any line of profession,

Mr. Boucher.

locality immaterial, experience in reinforced concrete construction and sewer design."

Doubtless, that advertisement will be read by several prospective employers who would much prefer that the applicant should have three or six months' practical experience, rather than a year's graduate study.

Mention is made of the fact that colleges admit all who apply and can pass the entrance examinations. This is true, and, as a result, many young men enter engineering courses who are unfitted mentally and temperamentally for that line of work. It seems to be such a waste of good time and effort to instruct young men in technical lines when they would make better mechanics, carpenters, clerks, or farmers. Before applying for admission, a young man should be made familiar, by parents or teachers, with the qualities essential to success in engineering; he should be observed and questioned as to his liking for and ability to solve mathematical problems, and, by various tests, his qualifications should be known to those who would be in a position to advise him in regard to his life work; for, although the engineering and technical studies will not harm him, and in certain ways will prepare him for any work, it would surely be much better for those who do wish to follow engineering as a life work if the classes contained only those and were not overcrowded with many who belong more properly in academic courses and do not care for the engineering training or propose to follow that Profession. This leads very naturally to the observation that so many graduates of engineering courses are found in lines of work in no way related to their training, and it would be largely eliminated if advice and thought were given to the future of the graduate, rather than to the haphazard method, so frequently pursued by parents, of sending their sons to attend an engineering school, because it "seems to be the proper place," or "the proper thing to do."

In a recent address, Alexander C. Humphreys, M. Am. Soc. C. E., President of Stevens Institute, said:

> "Many fathers and mothers come to me and tell me that their boys have a natural bent for engineering. Why? Well, they show great aptitude for making electric bell connections, or they are very skillful at the lathe. I generally tell them this: Will your boy apply himself to the hard study, perhaps, to him, the drudgery of mathematics and science? Otherwise, turn your attention to making your boy a good mechanic. The boy must have capacity for mental application besides manual dexterity."

In regard to lengthening the course beyond four years, Dr. Humphreys says in no uncertain language:

> "If the course is to be lengthened, who shall determine its duration; if five, six or seven years are needed, then why not seventy, for

a genuine student can always learn. One of the disadvantages of a college training, which must be offset by the greater advantages, is that students get to relying too much on their college training." Mr. Boucher.

Further, technical schools are seldom endowed as liberally as the older and better-known universities, and it is a well-known fact that the cost of a student's education is more to the institution than the latter receives in tuition, consequently, the larger the classes the more the institution runs behind in operating expenses, and, for that reason, if for no other, as many students as possible should be deflected into those colleges giving cultural or academic courses. Another very good reason for keeping the classes small, is that, by so doing, the professors come into closer contact with their students, which is always a great advantage to the latter.

On page 647,* the author gives a list, more or less complete, containing his ideas of entrance requirements. This list contains almost the identical subjects required for entrance to Stevens Institute in 1892, in addition to geography (political and physical), United States history, rhetoric, composition, and—probably most important of all—arithmetic. This last, for some obscure reason, the author seems to have overlooked. To the speaker, however, it is a most important subject, one which is constantly used, and in which proficiency and accuracy are most essential, and its use should not be subordinated to the slide-rule or "guessing stick."

As for foreign languages, the speaker is in accord with the author; they should not be required during the course, in spite of the view of one very much respected professor, who held the opinion that the study of foreign languages gives relaxation after the hour of mathematics or physics. A reading knowledge of modern languages is certainly an advantage to the engineer. It should be acquired in the high school, however, and, in order to keep up the practice, reviews of certain foreign technical papers might be required sufficiently often to insure that the student was not losing what he already had. The difficulty in after life is that language studies, probably not any too thoroughly taught in college, are completed (so-called) one or two years before graduation, and, when the latter occurs, the graduate is so "rusty" in his languages that the reading, being anything but easy, is consequently neglected and soon dropped completely; for the busy engineer in practice has all he can do to read a portion—a very small portion—of American technical literature, which each week and month is demanding his attention.

The course in engineering should be made pre-eminently practical. Its use in the future should be kept constantly in view, and

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*Proceedings, Am. Soc. C. E., May, 1912.

Mr. Boucher.

those subjects which will make the fresh graduate useful to his first employer should be elaborated—drafting and drafting-room methods should be insisted on and required. For five seasons the speaker was instructor in a New York City evening school, teaching mechanical drawing. He aimed to make the course useful and practical, devoting only a short time to mere drawing, but advancing the students rapidly to sketching from objects, then drawing the same in a neat and accurate manner, and finally tracing in ink; and, though a season's course lasted only six months, he has the satisfaction of knowing that several of the students, who had never before been in a drafting-room, obtained employment as tracers or junior draftsmen after their one season's course.

The author outlines a course of general engineering study covering four years and designed to produce graduates who shall be well educated on broad lines and acquainted with much that is actually required in their future work. The speaker finds very little to criticize in the work outlined. For several years, Stevens Institute has required, as a part of the course, attendance at lectures and recitations on "business practice," in which attention is given to accounting, depreciation, analysis of cost, specifications, estimates, contracts, and appraisals.

There is probably a diversity of opinion in regard to thesis work, but when properly conducted, and not consuming too much time, some good results may be achieved, for instance, in carrying out a test of a power station at a distance from the college, where the students must rely almost wholly on themselves.

In closing, the speaker desires to mention an incident, which occurred at almost the beginning of his practical experience. Application had been made to a rather prominent consulting and contracting engineer of 1897, who is still in practice, to enter his employ in a minor capacity. The answer, in letter form and preserved as a memento, reads as follows:

> "There exists at present no vacancy in my office, but my experience with college graduates has been such that I do not care to repeat that experience."

Fortunately, this attitude is rare, and will become rarer as the products of our colleges and technical schools prove their worth by being immediately useful after graduation.

In conclusion, the speaker desires to make this criticism of all the discussion by professors—that they seem to overlook or ignore the ultimate object of all the teaching, namely, to enable the graduate to secure a position in engineering work promptly after graduation, for that is what 99% of the graduates need. Professors are much inclined to require a too highly finished product, rather than a working knowledge of essentials. Engineers in practice know what they lacked when they started out in the world; they also know of the hours spent on work required in college, which has never been hinted at or needed in practice—work which can properly only come after years of experience in the active practice of the Profession and is only entrusted to those who have obtained standing and reputation by their years of experience; hence it does seem that engineers are very distinctly qualified to have a voice in the making of the curriculum which is planned for the education of their future assistants. Mr. Boucher.

Almon H. Fuller, M. Am. Soc. C. E.—Mr. McCullough has stated that engineering teachers should get together and standardize the courses of instruction. That sounds well, but he seems to have overlooked the fact that each man will have to deal with the situation as he finds it in his respective college, especially in other departments, such as physics, mathematics, and chemistry; and even though they should agree on a standard, there would be difficulty in taking it home and applying it. It is possible that some progress could be made in that way, but the conditions which exist would cause considerable difficulty in effecting a uniform change. Mr. Fuller.

The author also suggests a sequence of the various subjects which differs entirely from that usually followed. By this he hopes to give a certain amount of practical work the first year in subjects which will permit the students to do certain work during the summer, with the thought that if a man stayed by it without coming back to school perhaps the entire Profession would be the gainer. There has been much discussion on the proper sequence of subjects in an engineering curriculum. The usual order is to give much of the so-called cultural work first. Perhaps many would agree that this should be distributed throughout each year.

In talking with some of his own students, the speaker has noticed a greater inclination to take general work in the latter part of the curriculum than in the first. If given in the first part, it is thrust upon them; if available later, many will take it willingly. The speaker has heard practicing engineers suggest such an arrangement. Whether or not this is the better plan seems to depend largely on the spirit that can be instilled in the students at various times.

Mr. Green has well said:

> "Just what subjects are studied by the one being educated is a secondary matter; the chief concern is that the study shall be inspired and directed in such a way as to develop qualities which further happiness, efficiency, and capacity for social service."

When every instructor recognizes this, and realizes that it includes fundamental training for general resourcefulness—culture if you

Mr. Fuller. please—much progress will have been made. This is of greater importance than the particular arrangement proposed by the author.

Mr. McCullough suggests that a specification for engineering education be written by engineers. Professor Swain thinks that would not be practicable. Perhaps it would not be. The speaker can see many objections to it. However, as an engineering teacher, he would like to see the specification. He would welcome the opportunity of examining it, of comparing it with the present curricula, and of attempting to adapt it to the conditions that exist in the institution with which he is connected. If a representative committee of engineers would take the trouble to write such a specification they would deserve the thanks and possibly receive the approbation of the teachers. As Professor Swain has said, unless the men who write it were very closely in touch with the engineering colleges, it might not be very useful, but it seems to be entirely possible that it might bring out many points which engineering instructors could adopt with splendid advantage.

Office atmosphere may well be kept in mind in conducting courses in drawing and design. At the same time, it will not do to lose sight of the fact that, in the office, the intent is to mould the entire force into a smoothly working machine which will produce the greatest output; while, in college, the purpose is the development of the individual.

Mr. Allen. WALTER HINDS ALLEN, M. AM. SOC. C. E.—In the first part of the Nineteenth Century the young man who desired to become a lawyer secured his professional training by going into some law office where he would read law for several years. Later, law schools were founded, and, by attending one of these, a much better legal education was possible. These methods, however, did not afford a broad education, and, nowadays, the majority of law students first acquire a general college education, waiting to get their technical education until the age of twenty-two or later, when the mind of the young man is so much better able to comprehend and master the more intricate technical problems. Some of the modern law schools will admit only students who have received a Bachelor of Arts degree or the equivalent. These schools recognize the fact that general education is essential in order to produce the best lawyers and citizens; and that the man of twenty is not able, in most cases, to get the full benefit of his professional study.

This same condition is true to some extent in the study of medicine. Of course, there are and always must be schools of law and of medicine which admit students whose education has not advanced beyond the high school. Not all young men are able to afford the time or money necessary for a college course, and it would be most unjust to deprive them of an opportunity of entering these professions. It is generally recognized, however, that such a course is a desirable preparation for professional study. Mr. Allen.

At present the engineering schools of the country are at that former stage of the law and medical schools, when a previous college education was not a requisite for admission. The Engineering Profession is behind its sister professions in this respect, for a good general education is just as essential a preparation for engineering study and to produce the best engineers as for any other profession. Such general education need not be exactly the same for all professions. For one who intends to study engineering, much preliminary scientific study may be undertaken in mathematics, physics, and chemistry; but history, economics, literature, modern languages, and rhetoric should receive considerable attention. These subjects will prove of value, not only to the engineer in practice, and particularly as he attains more prominence in his profession, but they add to his culture and ability to stand well among his fellow men. They increase his power of enjoying the higher things of life.

An undergraduate college course is completed ordinarily at the age of twenty-two, at which time the young student, having reached the more serious period of life, is ready to take up the technical preparation for his life work. If he has finished his studies in pure mathematics and other elementary subjects, he can get a thorough engineering education with two or three additional years of study.

In another respect, the engineer may well profit by the example of the lawyer or doctor. After graduation it is a very common thing for these men to enter law offices or hospitals and work for one or two years with little or no compensation. They do not so much consider the financial side as the opportunity afforded to observe the best practice and to supplement their study at the professional schools. In the speaker's opinion, it is entirely wrong to assume the attitude that the man who has just completed his technical school course should begin immediately to earn good pay. He is not yet of any great value in his profession; the man who has not had the opportunity for education, but has started his practice at an early age, is, for a number of years, of much greater value to his employer. The trained man, however, has far greater possibilities in him, and nine times out of ten becomes the better engineer after he has had some years of practical experience. He himself should realize this and be content in his first years to make monetary compensation a consideration secondary to securing the best experience.

The speaker had occasion last winter to investigate the opportunities offered for certain young men, technically trained, and graduates of an engineering school, who had had two years of practical experience, to take a course of study that would give them a broad civil engineering education. These men were about twenty-five years of

Mr. Allen. age, good students and well equipped in mathematics and some branches of civil, mechanical, and electrical engineering. As far as the investigation disclosed, there is only one Eastern university or engineering school which has a regularly organized graduate school of engineering. This has been started recently, and marks, in the speaker's opinion, an epoch in engineering education in the United States. The number of young men who take up the study of engineering in a graduate course, after obtaining a general college education, is steadily increasing, and the opening of this graduate school is an index of the trend of engineering education.

It is a good omen, too, that this and other engineering societies are taking interest in the education of those who later will become engineers. The members of the Profession by their advice and interest can exercise a strong influence in securing the best training for their successors. This cannot be done effectively by bringing pressure on the schools themselves and by trying to dictate what they shall teach. The schools will furnish that kind of education for which there is a strong demand from the students themselves.

Outside engineers can do far more good by using their influence with young men who are intending to become engineers, by inducing them to secure a good general education first, and to pursue their technical studies afterward. The practicing engineer should encourage the beginner to take a broad view of his profession, to look to the future, and to map out his early training and practice with a view not so much to immediate financial success as to attaining ultimately the top of his profession.

Mr. Stengel. C. H. Stengel, Assoc. M. Am. Soc. C. E.—In order to substantiate some of the facts brought out by Professor Swain, pertaining to the statement that engineers should be graduated at the age of twenty-one in preference to a more advanced age, to give them an early start in the Profession, the speaker would state that he has had in his service a number of young graduate engineers, and, after careful observation, has found that their intellects are at a more advanced stage of development, their work more accurate, and themselves better men on the average, at the ages of from twenty-three to twenty-five than at twenty-one. The more mature the mind of the student at the time he is laying the foundation of his career, the greater are his intellectual powers, principally in absorbing and retaining the knowledge he is gaining, to develop his logic and reasoning.

When the young man enters college intending to take up Engineering, his course should consist in mastering thoroughly and conscientiously the fundamental principles which form the basis of the Profession in all its branches; then, with his power of application, he should be able to fit himself for any of its branches, and his rise will soon be assured, if his energies, resourcefulness, and ambition are applied to his work. Mr. Stengel.

As stated, it is the personality and self-reliance of a young man entering the engineering world, together with the thoroughness in which his mind is developed in not only the fundamental principles underlying his Profession, but in careful analysis and accuracy in the performance of any work he may pursue, that mean success; and to accomplish this he should have the full confidence of his tutors and the co-operation of his parents (as stated by Professor Swain) in the moulding of his career.

Charles Warren Hunt, M. Am. Soc. C. E.—The general subject of the education of the engineer is of great interest to the speaker, inasmuch as, for more than twenty years, he has been in a position which has enabled him to form an opinion of the results of modern technical training. Mr. Hunt.

Professor Swain has stated certain logical, broad, and proper basic principles on which engineering education should be founded, nevertheless, in the speaker's opinion, the tendency of the modern technical school is to become more and more narrow.

A boy who wishes to become an engineer must decide, practically upon matriculation, which special branch of this great Profession he will follow: Civil, Mechanical, Electrical, or some other. During the course in whichever specialty he chooses, he is forced to spend many hours in working out details of that specialty (in many cases without even a suggestion of a study of modern languages, history, literature, or in fact of any of the humanities), and, after four years of hard grinding, is graduated as the particular type of engineer indicated by the title of the course pursued. He must then secure a position for which that preparation is supposed to have fitted him—he has no other option—and then follows a period of years during which, in the struggle for existence, his nose is kept so close to the grindstone that he has no time even to look about him for broadening influences; so that, when he reaches the age at which he should be most productive and efficient, he is not fitted to take and keep the position, in the social, political, or business life of the community in which he lives, to which his intellectual attainments and constructive skill entitle him.

It is trite, but true, to say that the engineer is the pioneer of all civilization, as well as one of the most important factors in its advancement; and it is then most natural to inquire why his position among his fellows is not commensurate with his achievements. In the speaker's opinion, it is because he is not enough of an all-around man; he is not broad, not capable of thinking clearly and quickly along any other lines

Mr. Hunt. than those to which he has given up all his formative years. He does not, therefore, succeed in impressing his personality on his fellowman, although he has not the slightest difficulty in so doing on his fellow engineer.

The speaker believes that the modern system of engineering education is, speaking broadly, responsible for this condition. He does not know enough to attempt to discuss any of the details of curricula or class-room, but would like to go on record as believing that the specification for a properly equipped technical graduate should not be that he should be able immediately on leaving school to be valuable to an employer in any specialty, but that first of all he should be full to repletion with knowledge of the fundamental laws and principles of the exact sciences on which the sound practice of engineering in all its branches must be based; and, in addition to this, his attainments outside of technical matters should be broad enough and fundamental enough to enable him to become a man of the world. It is time enough for him to specialize when he has found out what he is best fitted for, and what his opportunities are. To be successful, an engineer must not only be able to do the technical work which comes his way, but he must be able to get it, and his ability to hold his own with men of other professions and in the world of business must ultimately decide whether he shall be in fact, as well as in name, a professional leader in the community, or continue to be regarded by the general public as a sort of an upper class mechanic.

Mr. Blanchard. ARTHUR H. BLANCHARD, M. AM. SOC. C. E.—It is not the speaker's intention to discuss Mr. McCullough's paper from all standpoints, but to call attention briefly to certain phases of the subject which might not be treated in the general discussion.

The speaker wishes to emphasize the author's recommendation that advanced specialized work can be taken profitably by graduate engineers, provided the period of attendance and other details are arranged satisfactorily. Up to this date, very few examples of educational work conducted along these lines are at hand. One case, however, which is conducted on the plan proposed, is that of the graduate courses in Highway Engineering at Columbia University. The period in which these courses are offered is from December 1st to April 1st. Hence an engineer desiring to take all the graduate courses in highway engineering and allied subjects, which fulfill the requirements for the Master's Degree, will necessarily be in attendance for two winter periods, the equivalent of one collegiate year. Although candidacy for the Master's Degree requires as a prerequisite a Bachelor's Degree, nevertheless, mature men are admitted to any courses for which they are qualified, and may take any number of courses.

Mr. Blanchard.

As this plan is somewhat of an innovation in engineering education, it may be of interest to cite certain facts in connection with the attendance during the winter period of 1911-12, which was the first period under this plan. Although the graduate courses were not brought to the attention of engineers until November, 1911, there were in attendance fifteen men affiliated with highway work, thirteen of whom registered as candidates for the Master's Degree. It is of interest to note that this group included men connected with State highway departments, contractors' organizations, municipal departments, engineering-sales departments of manufacturing companies, county highway departments, and consulting engineers' offices. The experience of these men ranged from one to twelve years. They came from widely distributed localities, Massachusetts, New York, Pennsylvania, Maryland, North Carolina, Alabama, Panama, and British Columbia being represented.

The idea, as suggested by Mr. McCullough, that men taking advanced courses should work on special problems is followed out at Columbia, and it is of interest to note that the founding of several research fellowships by various manufacturing companies is under consideration. The research workers holding these fellowships will investigate problems of particular interest and value to the manufacturing concerns founding them. It is expected that many problems of wide interest to those engaged in highway work will be thoroughly investigated through this medium.

The speaker hopes that the author will elucidate his remarks relative to the injection of an office atmosphere into the classroom. Does the following plan, adopted in connection with the graduate courses in highway engineering at Columbia, approach Mr. McCullough's ideal? This plan consists in the employment of a large number of experts in various fields connected with highway work to act as Non-Resident Lecturers in Highway Engineering. These lecturers cover certain subjects with which they are particularly familiar and their topics form an integral part of the various courses. Although the regular officers of instruction are actively connected with highway work or allied subjects, it was thought that lectures, based on the plan outlined, would tend to broaden the viewpoint of the graduate students, besides bringing them in contact with men of the highest standing in this branch of the Profession.

Mr. McCullough evidently does not fully appreciate the value of a training in French and German. He considers this subject from two standpoints: first, ability to converse in a foreign language; and, second, ability to read foreign literature. The speaker thoroughly agrees with the author in his implied criticism of the time wasted, both in preparatory and technical schools, in the attempt to acquire

Mr. Blanchard. the ability to converse in French and German. He feels, however, that an entirely wrong impression is given when it is intimated that, for those who have never taken French or German, only a few weeks' work is necessary with a phonograph or in special schools in order to acquire ability to transact business or discuss engineering problems with those speaking a foreign language. Based on the speaker's experience with the use of foreign languages in Europe, and his knowledge of the methods used in teaching French and German in preparatory and technical schools, the following recommendation is offered for consideration: In all foreign language courses for engineers the entire time should be devoted to a thorough study of grammar and to translations. The time now devoted to the reading of French and German in the original is generally wasted. In many cases the pronunciation used by American teachers is poor, and hence those who attempt later to converse in foreign languages must forget the faulty pronunciation acquired previously. An engineer who is called on to use French or German in Europe will find it profitable, after mastering the vocabulary covering his particular field of work, to devote the requisite time to association with a French or German teacher and to living with a family where only the foreign language is used, in order to acquire the native pronunciation and have an opportunity to converse in the foreign language.

The author uses the common argument that "everything of value appearing in the foreign papers is quickly translated." Naturally, the deduction is that engineering literature of value to American engineers is translated and reprinted as it appears in the foreign press. In the field of highway engineering, such is certainly not the case. Before devoting a year to the investigation of the construction and maintenance of roads and pavements in foreign countries, the speaker attempted to review thoroughly the practice of the leading countries of Europe. It was found, however, that the so-called translations referred to gave a very inadequate idea of current practice in foreign countries. The result of the speaker's investigations showed that European engineers had adopted many methods, in connection with the construction and maintenance of highways, with which American engineers were not familiar, and likewise that the few references to this practice in the English press gave a perverted view of foreign practice. That American engineers in many fields may profit materially by thorough study of foreign practice does not require extended argument. Many instances in highway engineering have occurred in which both failures and successes of foreign engineers have been duplicated as experimental work in the United States where such work would not have been undertaken if the experimenters had been familiar with the results of foreign practice. The speaker has in mind an

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experiment described by an American engineer, and labeled as a new invention, which had been in use for a number of years in Great Britain, Germany, Austria, and France, and had been described in foreign periodicals. The practice in highway engineering in English speaking countries is very well covered by the technical press of the United States, Canada, and England, but it is the exception to find the best articles printed in the *Annales des Ponts et Chaussées, Annales des Chemins Vicinaux,* and *Le Génie Civil,* of France; the *Annales des Travaux Publics de Belgique;* the *Zeitschrift für Transportwesen und Strassenbau,* and *Der Strassenbau,* of Germany, translated and reprinted or abstracted in the technical press of America.

Mr. Henry.

PHILIP W. HENRY, M. AM. SOC. C. E.—More or less has been said about education in different branches of engineering, as if it made considerable difference in a man's career whether he takes a course in mechanical, mining, electrical, or civil engineering. It is difficult to differentiate these courses, and the speaker does not think it is necessary to do so. It is the quality of instruction that counts, rather than the subject. A course in mining engineering, properly given, will better fit a man to be a mechanical engineer, than a course in mechanical engineering improperly given. The degree which a man obtains on Commencement Day does not make him an engineer, but indicates, or should indicate, that he knows how to work intelligently on any engineering problem which is set before him. In the class-room he has been compelled, every day of his four years' course, to concentrate his attention on a definite problem, and demonstrate its solution on the blackboard or in some other concrete way. When, after graduation, he takes a position, no matter how humble or in what branch of engineering, he still finds that there is a daily problem to solve, and that, through his training in proper methods of application, he is able to solve it more easily, and thus advance more rapidly than a man, who, with the same mental endowments, has not had the advantage of the same kind of training. In addition to this mental training, good for any kind of business—dry goods or otherwise—the graduate engineer has the advantage of knowing where to go for any detailed technical information bearing on the subject in hand.

Many students in engineering schools have only sufficient means to carry them through the course, and, of necessity, must accept the first position open to them. If, therefore, a man who has taken the course of mechanical engineering finds that the only opening is in the office of an engineer whose specialty is sewer construction, he should not despair, but should take that or any other position which may offer advancement, feeling confident that his training will come into use and that he will have the advantage over all

Mr. Henry. his competitors in his ability to work thoroughly and intelligently. By steady application and by taking an interest in his daily task, he will find advancement sure, even though it may not be in that branch of engineering for which he originally prepared himself.

Mr. Rogge. JOHN C. L. ROGGE, M. AM. SOC. C. E.—Professor Swain has stated that when one is studying engineering, he cannot tell what business he will follow ultimately. The speaker would like to say a word or two in reference to engineers engaged in lines of business other than engineering, and to show how circumstances alter cases, using his own career as an example.

He was educated as an engineer and followed the Profession for about twelve years. During part of this time he was employed in one of the New York City Departments where he rose to be Chief Engineer. While thus employed, he was so impressed with the success of various contractors who worked under his supervision and who had little or no education, that when the opportunity came, he resigned his position and entered the business world. The venture was a success, and he has never regretted the change.

While a man's environment, opportunity, and temperament are always large factors in his success, the speaker believes that an engineering education would not be found to be a handicap in any business or profession, because it trains one to reason, to plan, to be keen in observing, to be able to make quick and accurate decisions, and not to take anything for granted, all of which are valuable to one who is in commercial life. A prominent New York lawyer, who was graduated from Stevens Institute as a mechanical engineer and subsequently took up law as a profession, informed the speaker recently that his engineering education had been of great benefit to him in the study of law.

A man who has followed the Engineering Profession for a considerable length of time, however, is apt to be timid as compared with the every-day business man, because of the extreme accuracy demanded by engineering work; but if he will follow engineering just long enough to learn to apply what he has studied in practice, he will then be ready to take up any other line of work or business which may suit him better, or in which there are more financial returns.

To young men studying engineering the speaker would say that there are many opportunities in the commercial world where an engineering education can be used with profit.

Mr. Higgins. CHARLES H. HIGGINS, M. AM. SOC. C. E. (by letter).—This paper is very interesting, expressing as it does, a natural and not uncommon point of view toward this vitally important subject.

The author appears to take for his premises the following: "The engineer should merely give to the teacher his specifications for a good assistant, and the teacher should try to follow the specifications." For those who accept the foregoing, it can only be a matter of deep regret that the author did not furnish a sample copy of the specifications, including a form of contract and a notice to bidders. The brief description contained in the paper, can, in no wise, alleviate the disappointment felt in not finding the proposed specifications for the finished product.

Mr. Higgins.

The author states that "it should not be a difficult matter for teachers to standardize a course of instruction in engineering"; but is it not a little too much to expect of those "whose sole function in life is to prepare assistants for the engineer, and train those who in the future will be engineers," before they receive copies of "a specification for a good assistant" and know the conditions to be imposed by the contract? To illustrate: Some forms of contract contain a clause providing for liquidated damages to the amount of $100 per day for failure to complete the work within the specified time, in full accordance with the specifications. The contracting teacher would have to take such a clause into account in preparing his bid and planning his future course. In all fairness, a copy of the specifications should be sent before the method of carrying on the contract is required.

Discipline and specialization, of course, are good, but is it not a little severe to prescribe, even for teachers, a "sole function in life"? The writer would not be quite so severe; he thinks that he would allow the exercising of at least one more function, even in the case of a hardened offender.

Many engineers not only receive their assistants from colleges, but they send their sons to them, and that gives another point of view.

There is much in the latter part of the paper which the writer would like to endorse heartily, particularly the advantage to be gained in arranging the course so that a man will have obtained some training that will serve to recommend him for a position in engineering work during the summer vacation following the freshman year. Also, the recognition, in the reference to 6 universities and 200 technical schools, of the fact that there may be a distinction; and, above all, the emphasis laid on the importance of a training in English, including public speaking, and in economics.

Perhaps engineers expect too much as assistants, of young men just out of college. Professors of engineering probably know the difficulties of training in college, just as practicing engineers do of continuing that training later in the office. Should the student be trained in details as suggested, it may very well be that he will not detail any steelwork for several years after leaving college; meanwhile, methods of detailing will have changed, or he will find that the office he enters has methods which he must learn to follow.

Mr. Higgins.

Is it the function of the college to take the place of office and field training? The writer thinks not. What it can do is to educate its students in the underlying principles of Nature, and broadly, in the methods of their application, for the use and convenience of Man; and make him more receptive to experiences and capable of interpreting them in the light of the known laws of Nature.

After all, there are distinctions between skill, knowledge, and education. The training which makes the best assistant during the first year out of college is not by any means of necessity the best for the recipient. The college may owe something to the practicing engineer, but it certainly owes vastly more to the students and their parents. The human element will always remain. After all is said and done, engineering is for men and not men for engineering.

Mr. Buerger.

CHARLES B. BUERGER, ASSOC. M. AM. SOC. C. E. (by letter.)—Mr. Green has stated that the aim of immediate usefulness to the future employer may properly be made a secondary consideration in the determination of the curriculum; and it is quite likely that this aim of early usefulness would fail. A course, or a student's electives, may be intended to fit him for a particular position, such as assistant to a consulting engineer, and such position he may never have occasion to fill. Outside of domestic servants, the employé in a subordinate capacity is far from being a free agent, with "liberty" to contract, the Court of Appeals notwithstanding, his occupation being rather a matter of accident than of his wishes or qualifications.

The best curriculum is the broadest one; one which of itself will fit the student for no special position, but will give him the capacity to learn most readily the duties of any one of many possible positions; and his practical education will be obtained, as Mr. Green points out, after he has left school.

Mr. McCullough has not dwelt on the method of teaching, and that is a feature which a teacher should be best qualified to decide; but any one who has been a student has a right to a small voice in the matter. As a rule, the teaching system now comprises 8 months of study per year, 20 hours per week, the time being divided approximately between lectures, quizzes, and the laboratory, the last including shop, field, experimental, testing, and drafting work. In addition, students are expected to put in from 4 to 5 hours each day in private study. The writer would substitute a school year of 50 weeks, with 44 hours of study per week, say 8 hours each for 5 days, and 4 hours on Saturday. He would abolish all lectures and all quizzes, leaving only the laboratory work and the examinations of the present system.

Of the college men with whom the writer came in contact during their student days, numbering, perhaps, 500, four-fifths went through the prescribed courses in a perfunctory way, regarding them as necessary evils, the solace being the shortness of the school hours, and the

Mr. Buerger.

time available for other things. Friends of these students in the commercial world were spoken of as being at work; the students themselves were at college, never at work in college. These are only words, but they represent correctly the student's point of view.

The boy of 16 who goes into the business world puts in 8 hours at his daily task, and be he clerk, mill hand, or rivet boy, he takes this length of time as a matter of course. It does not occur to his employer that the boy should work 4 hours a day at his shop, or office, and do the additional 4 hours' work at his own home, should it be work that could be done at home. If the employer did this, he would get exactly as much done in the 4 hours at home as the college student does in his home study. Nor could this boy get 4 months' vacation a year, even without pay, for the employer would consider steadiness of application a primary qualification.

This lengthening of school hours and elimination of home study has not the same meaning as the recent changes in the New York public school system, which have eliminated in effect any study of any kind on the part of the pupil. It is, in fact, the reverse. The study time is moved into the school hours, and these school hours are doubled thereby. The study time is made an essential part of the course; it is even made the only essential, and replaces entirely all lectures and quizzes which, at present, occupy the greater part of the school hours.

This teaching method, then, consists of, say, 32 hours of study per week under supervision, and 12 hours of the various courses belonging under what has been called laboratory work.

The ordinary school lecture is an abomination. In the Stone Age, it was no doubt a proper means of teaching; now there is no excuse for it. It is true that many instructors cannot find books which they consider suitable. With their judgment, the writer will not quarrel; but, even then, they question the value of their lectures by giving the students the substance in mimeographed sheets.

The ordinary quiz is a useful means of teaching the instructor what the student knows, but it is no help in teaching the student what he does not know, and that is what he is after, always granted that there are some capable teachers who make a success of these methods.

Studying under supervision means necessarily individual instruction. This would mean a larger number of instructors, except that it is entirely feasible to use the more efficient students as aids to the instructor to assist the less efficient ones. It would be better, also, to change the terms to correspond to the change in method, and say that the student instructs himself from his printed matter and that he has a supervisor to render necessary aid.

The writer thinks that further elaboration is unnecessary; it can be expressed in two sentences:

Mr. Buerger. 1.—Make the student put in a full day's work every day, and watch him so that he does it.

2.—Apply correspondence-school methods to the college, with the additional advantage of personal contact and personal help.

Such a system will make the student, not a passive receiver, but an active studier, and when he is that, there will be little complaint as to his curriculum.

Mr. McCullough. ERNEST MCCULLOUGH, M. AM. SOC. C. E. (by letter.)—As a teacher, Mr. Garver feels that the writer has presented a paper criticizing teachers, whereas the intention was to assist them in engineering schools by giving suggestions for the better preparation of embryo engineers. The attitude of mind often warps judgment, and, as Mr. Garver read things into the paper that were not there, the writer would suggest that he read it again. For his information, it may be stated that in the Michigan Mining College, Houghton, Mich., the University of Chicago, Chicago, Ill., and Valparaiso University, Valparaiso, Ind., the system of 12-week terms, with new classes in every subject beginning with each term, has been in use for many years. The writer fails to see that these schools have a larger proportion of teachers to students than other schools. The professors have to work a little harder than the majority of professors, almost as hard, in fact, as the majority of engineers in active practice, when the latter are fortunate enough to have a job. The writer understands that a number of private schools also have their doors open throughout the year, and the proportion of teachers to pupils is about the average.

Captain Pillsbury is a graduate of, and has been a teacher in, the finest vocational school in the world. The students are selected after a very careful and severe physical examination followed by a no less severe mental examination. Their conduct is rigidly guided throughout four years of as strenuous work as men can do and survive. This training, however, is in preparation for a position guaranteed to all graduates. A man is even paid while learning. A few years after he has reached his prime, and long before he has outlived his usefulness, he is retired on a pension which, to many engineers in private life, looks like affluence. Criticism made by a man trained under such a system is not as valuable as it might be, for he knows nothing of the trials and tribulations of the average engineer, so long and humorously referred to as a "job chaser." The average student of technical schools has to go through school on very short allowance, and many have to earn the money. On his graduation, no kind Government engages his services. He must strive hard to get a position, and must compete with men having less schooling and more practical experience. The competition is becoming more keen each year. The following* illustrates this point:

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* Extract from an article by Edgar Marburg, M. Am. Soc. C. E., entitled, "Engineering Graduates and the World," *Engineering News*, July 4th, 1912.

Mr. McCullough.

> "It may be of interest to add, that of the total number of graduates, 1 258, beginning with the class of 1873, more than one-half have graduated since 1904."

The graduates referred to are from the Engineering Department of the University of Pennsylvania. The writer has obtained printed matter from other schools, and a study of the subject shows that the foregoing fact is true of the majority of engineering schools. There is no reason for such an increase except widespread advertising, and, in the paper, an endeavor was made to point out a way of altering the present sequence of studies, in order that there might be a continuous elimination of the unfit, beginning with the first year in school. The writer is sorry he failed to make his meaning clear.

The writer also fails to understand where his critics gain the impression that he advocates less mathematics than the present curricula provide. He said "Either mathematics should be taught in a manner that will provide the student with a useful tool, or the time should be given to some other subject." He did not decry the value of a rigorous course in pure mathematics, but he did criticize the slipshod manner in which the subject is taught in too many schools. However, as the question has been raised, it may be said that many eminent educators have stated lately that too much emphasis has been laid on the value of mathematics as a cultural study. That study develops only the mathematical portion of the brain. It does not tend to broaden the mind, and therefore, should be taught rigorously only to those persons who may be apt to require it in later life. It is more difficult to remember than language, and for those who have no mathematical bent it is time wasted to teach anything more than high school mathematics, purely for cultural purposes. The writer fails to see why a "practical" course cannot be "rigorous," and would recommend to his critic a perusal of the book referred to in the paper.

Mr. Constant's discussion meets with the writer's approval. He has evidently read the paper carefully, and it is thought that he must have been in far better touch with actual conditions than the majority of teachers in engineering schools. He goes to the heart of the matter in the following paragraph:

> "After all, however, it is not so much the precise nature of the curriculum as the manner in which the subjects and the students are handled that is important. How to bring out the very best in every man, to stimulate his interest and devotion to his work, and, at the same time, to eliminate the lifeless and the small group of deficients always to be found at the lower limit, who, by sheer persistence, in point of time, finally get through, no more fit, perhaps, at the end than at the beginning—this is the real problem of the engineering school."

Compare the foregoing with the last three lines of the second paragraph of the paper.

Mr. McCullough.

For many years the writer tried to get into teaching work, but for three reasons was unable to do so: First, he had never been a teacher in a school of university grade; second, he might have received minor appointments carrying considerably less pay than he could average in practice; third, he was voted against by the faculty in four institutions because the professors said their experience with teachers having many years of practical experience was as a rule unhappy. The man of more than ten years' practical experience does not mix well with the average faculty man. The result is an emulsion rather than a mixture.

Consequently, the writer has been compelled to satisfy his desire to teach, in part, by conducting classes in vocational subjects in institutions to be found in most large cities.

Few teachers in engineering schools are there from deliberate choice. Too many have entered the work because a teaching position was open at a time when they were out of a job. They took the low pay of an instructor to tide them over a winter, and ended by staying permanently. A large part of a teacher's work consists of lecturing, and few men are harder to listen to than the average teacher in an engineering school. A friend once said of a widely advertised professor, "I never listened to a man so reluctant to part with his conversation." The students who had to sit in his classes said of him that he lacked tact, and was so difficult to follow that they failed to see why he was kept year after year. The writer believes there is a far larger proportion of unfit teachers than of unfit men in any industry. Is it any wonder that a man like Mr. Taylor should prepare a paper entitled "Why Manufacturers Dislike College Graduates?" The writer thanks Mr. Constant for his conscientious discussion.

Mr. Green's discussion reads like a high school thesis, and does not contain a single original thought. All he wrote has been written before, and the writer has read such things in discussions on engineering education printed two or more generations ago. This is not a new discussion, by any means, neither can any one put forth really original ideas on the subject. He can only voice the ideas of groups he voluntarily seeks to represent, to the end that there may be improvement. "Qualities make up education, not knowledge." How often that idea is expressed in different words. Lately, some big business man said "I find it is not so much what a man knows, as how he knows it, and character coupled with opportunity, rather than knowledge, determines success and failure." Life is one-half opportunity, one-third ability, and one-sixth technical knowledge as Mr. Green and other young men graduated as engineers will discover sooner or later. It is easily possible to give too much scientific and technical instruction to some young men who would have been served if sent out earlier with somewhat less education, as education is defined in the usual

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academic sense. Mr. Green insists on the duty of the employer to educate the engineers he employs. Does he not know that this is precisely what every employer does; and it is also very costly education. The ultimate consumer pays for it. The writer insists, as the result of twenty-five years' experience since leaving school, that the main object of the majority of engineering schools is to train young men to be competent assistants, and, if blessed by opportunity and backed by ability, they may develop into engineers. First, we must define an engineer, and an attempt to do this was made in the opening paragraph of the paper.

The writer has interviewed every man whom he found willing to talk, and in this way has obtained the opinions and ideas of many hundreds. The majority took up engineering because they wanted a college education, and their parents were willing to give it to them provided they studied engineering, which popularly is supposed to be very lucrative. The prevailing opinion is shown by the effect the Panama Canal had on the enrollment in engineering schools in 1900, many people trying to have their boys graduated in time to secure a position on that work when it would start, in 1903 or 1904. The writer has been told by forty-seven young engineers who were graduated about that time that this was their sole reason for studying engineering. Contractors and other employers do not take engineers fresh from the schools; they take minor assistants. In fact, the fresh graduates usually have a hard time securing employment, few men caring to give them the necessary experience. They must take clerical work, or anything they can get, and then depend on their native ability to go up. They are, in effect, educated by the employer; not as the bricklayer is trained, because there are few bricklaying schools. When trade schools become as relatively plentiful as engineering schools, the large employers will discontinue whatever instructional courses they are now presumed to have, although, in his knowledge of such courses, it is admitted that Mr. Green seems to possess more information than the writer. The writer asks Mr. Green to read carefully the title of the paper and the third page. Engineering education was not therein dealt with as a training in pure or applied science. The title is "Engineering Education in its Relation to Training for Engineering Work," therefore, education was discussed purely from the vocational standpoint.

Mr. Saurbrey, in his opening paragraph, takes occasion to mention the difference between "Engineering Education" and "Engineering Training." A teacher of business once said "When writing a telegram, use no punctuation marks. Hand it to a stranger to read, and if he gets your meaning then send it. If he does not get your meaning, re-write it; but remember, no punctuation." One often neglects to write so clearly that he can be free from criticism by men

Mr. McCullough. who split hairs and hold rigorously to definitions. Mr. Saurbrey objects to the use of the word "pose." As he understands that word, the writer was unfortunate in using it, and perhaps might have said: "The well-read man is generally able to pass as a cultured man." To some, the use of the word "pass," in this connection, still bears too strong a resemblance to a game of poker, therefore is again "pose." Mr. Saurbrey has dilated too much on the unfortunate selection of that word. The writer meant to say that the man who reads deliberately from choice, instead of having manufactured learning stuffed into him by teachers, generally makes the best impression on people who look on the possession of real knowledge as being an evidence of culture. The "poser" was the last man in his mind when he penned the unfortunate sentence. Mr. Saurbrey goes afield, however, in leaving the technical school and going back to the home and the common schools. The writer insists that the technical and engineering schools take the raw material as it is delivered, and, from the first day of school, begin to put in motion a proper law of selection; that and nothing more. His curriculum is practically that of all technical schools of to-day. His arrangement, however, departs from the common one for the purpose of assisting in the early elimination of the unfit, and the dilation of the sense of perception on the part of those who took up the work ignorantly and have in them the germs of engineering ability. A liberal offering of electives gives every man full opportunity to travel as far as he likes in the paths of the scholar, nay, even in the path of the dilettante in matters bookish. Those who like more mathematics than is required can indulge their taste. Those who hanker for the ability to read foreign languages can have their hankerings satisfied.

Mr. Cohen has made a real contribution to the discussion, and is pretty well in accord with the writer in his ideas on the subject, as specifically dealt with according to the title of the paper. Mr. Stengel seemingly has some difficulty in getting at fundamentals. The writer believes that, when a young man is shown how to do a thing and then, in the course of his studies, is given the reason, he is far more likely to take an interest in his work than if he is given a two years' dose of "why" before getting at the "how." The writer, in handling his classes, obtains the best results by training men in doing things, and then giving the reasons when some curiosity is excited. Take the planimeter for example: It was required by a higher instructor that the pupils give the mathematical theory of the planimeter in an examination. The writer first taught the use of the planimeter, and areas were found by it. Then he bent a wire before the class and made a hatchet planimeter. With this crude instrument areas were measured with an accuracy that was surprising. After this preliminary treatment, the elucidation of the theory and the presentation of the funda-

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mental equations involved no work, but was attacked with zest. However, to this day, the writer cannot see what difference it made, for the instrument is a commercial product and no engineer is going to make one, unless it be the hatchet planimeter in its crudest form; and then he does not have to know the theory.

The writer is pleased to learn of the work being done at Columbia University, as described by Mr. Blanchard. The injection of an office atmosphere in graduate courses is well attended to by the method adopted by Mr. Blanchard when it is considered that every man taking the course has had undergraduate instruction, and, subsequently, considerable practical experience. Such men, however, do not require the office atmosphere, because they understand the conditions of engineering life. They really are after the academic side. The office atmosphere mentioned by the writer is something which the undergraduate should breathe from the first, in an engineering school. It cannot be imparted properly when "inbreeding" is the rule in selecting members of the faculty. No man should be employed as an instructor in an engineering school until he has had not less than five years' practical experience of a good character. No graduate of the school should be appointed an instructor, for there are plenty of engineering schools turning out fit men. A man should not be an assistant professor until he has served some time as an instructor; and a graduate of the school can be appointed as an assistant professor, provided he has had not less than five years' practical experience and has also served some years as an instructor in some other school.

Willingness to accept a teaching position should not count so much as a proven ability to teach. An engineering teacher should be a fluent and not a hesitating talker, as so many are. He should be interested in his work and in his students. The writer knows some professors who have nothing to do with their students outside the classroom, and these professors are not men of high standing, it being his observation that the higher standing the teacher has as a man the more of a common man he is with his students. Given teachers with practical experience who know the ups and downs of the "job chaser," the proper tinge of office and works atmosphere can properly be left to them. The writer knows what he would do had he the opportunity to conduct an engineering school, but cannot go into details in a paper such as he presented nor in any discussion. If the teacher cannot eliminate a proper amount of academic atmosphere and substitute a wholesome amount of office and works atmosphere, then he belongs in the liberal arts department rather than the engineering department of the school in which he holds a position on the teaching staff.

Mr. Blanchard does not fully understand the writer in his remarks on the teaching of languages. His criticism of language teaching was

Mr. McCullough. similar to his criticism of the teaching of mathematics in the average school. The writer had the usual high school Latin and Greek. He also studied German years ago and later French. Some years after leaving school he obtained a position where a knowledge of Spanish was necessary, so he added that language to his stock. Of all this language work he retains practically nothing, for he has had no occasion in late years to make use of it. He can read articles in any three of the modern languages mentioned, by keeping a dictionary close to his elbow, and he does a little reading in this way occasionally. Of conversation he is wholly incapable, except that when going home in the street cars he occasionally enjoys family gossip retailed by Germans who imagine no one in their vicinity understands the tongue. Even his meager knowledge of modern foreign languages is superior to that of 90% of the engineers with whom he comes in contact, hence his criticism of the manner of teaching languages in engineering schools, and his suggestion that this study be elective. The engineers who will really profit by it will take up this work; the "ninety and nine" who go at engineering as a vocation, and not with any idea of the study of engineering as a cultural matter, nor with the idea of being teachers, nor with any idea of doing research work, will not study foreign languages at school from choice, unless the credits gained thereby are more easily obtained than by any other method. The writer's criticism did not extend solely to the waste of time in attempting to get a conversational knowledge of a foreign tongue, but to the very poor way in which, as a rule, the study of foreign languages is taught in the majority of schools to first- and second-year students, who are obliged to take the work. It is really a device for piling up credits.

To a certain extent, the writer agrees with Mr. Boucher on the subject of the 6-year course in engineering schools. He stated in his paper a belief that engineering schools of the future in the United States will probably call for a minimum of 6 years' work. The reason for this belief is that there is a widespread demand on the part of teachers that this be accomplished. The tendency in this direction is so strong that no power on earth can prevent it from being tried. Much of the elementary work now being performed in technical schools of college grade will be attended to in technical high schools, so that in the future we shall have the Trade, the Vocation, the Business, and the Profession of Engineering, all recognized and taken care of in schools ranging from trade and high schools to the largest universities. The greater number of teachers will come from schools where the professional ideal is held, that is, these higher schools will train teachers, many of whom it is to be hoped will have considerable active practice in earning a living as vocational men before taking up teaching. The writer, in his paper, took the vocational school, corresponding to the present technical schools, as the one in which engineers should be most interested. The present 5- and 6-year courses, however, give very little, if any more, than the 4-year course in some schools, for the latter require from the students more hours per week than schools with the longer courses.

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Mr. Boucher also referred to the writer's neglect to include arithmetic as an entrance subject. The writer has taught much in evening schools, and, as a result of his experience, can say that arithmetic is taught so badly in the ordinary American school that it will be better to omit it as an entrance subject, assuming that it was completed before the student entered the high school. His experience as an instructor in evening schools, and also as an employer of office assistants and draftsmen, compels him to say that the schools of America have much to learn from the schools of Europe in teaching arithmetic. It is stated in the paper that in the first year students should devote one hour each day to going through the examples in Sanborn's "Mechanics' Problems." This will give them drill in arithmetic. He mentioned also that the second-year students should be drilled on problems apt to arise every day in actual work, these problems all being arithmetical rather than algebraic.

In reply to Mr. Hunt the writer will say that it is a fact that the "tendency of the modern technical school is to become more and more narrow." This the writer wishes to counteract by his proposed arrangement of the curriculum. It will be noticed that he adheres closely to essentials throughout, merely changing the order of their introduction, with the object of broadening the minds of the men taking the work. The young man is interested in the practical rather than the ideal. He studies engineering in order that he may be enabled to earn a living. It is a mistake to cram his sciences, economics, psychology, etc., down his throat during the years when he does not and cannot appreciate them. He should be given at first the things which will make him most immediately useful to his prospective employer, to the end that the narrow-minded and undeveloped boys will be worked off by stages, leaving those whose minds develop with the school work. The humanities, therefore, come at a time when the student is maturing and the topics of the day begin to interest him. The young boy is intensely egoistic, albeit without knowing himself to be so. At about the time he reaches the age when he can vote, the problems of society begin to interest him; also, at this age, he is, as a rule, unselfish and gregarious. If he now takes up the subjects that interest men and women of standing, they will make an impression on his mind which can never be effaced, and, later, when he achieves success, he will not be considered a sort of upper-class mechanic.

Mr. Henry states that the quality of the instruction counts, rather than the instruction. It is precisely this point that the writer sought

Mr. McCullough. to bring out. He believes that the quality of instruction in the majority of engineering schools can be vastly improved. The essentials have been pretty well settled by a century of teaching. The order and the manner in which these essentials shall be imparted are now matters requiring settlement, bearing in mind that 99% of the students in engineering schools attend these schools for vocational training. When a man is drilled enough in mathematical, physical, and chemical sciences to read intelligently along the lines of his calling, he has obtained a great deal. It has been stated* that "a technical education can do nothing more beneficial for a man than to make him familiar with the best and most authoritative engineering literature." Granting that technical education gives him this much, let us add certain other broadening studies of a general nature, so that the graduate of the engineering school will be a good assistant, a well-read man, a good citizen. Those who leave before graduation will be good minor assistants, whose further development will depend on their inheritance of mentality and family environment.

Mr. Allen will find on investigation that a comparison between engineering, law, and medical schools is not at all unfavorable to engineering schools. He says "nowadays, the majority of law students first acquire a general college education, etc." It would be interesting to know where he obtained the data on which to base this assertion. A majority of the men admitted to practice as attorneys are not graduates of law schools, even to-day. A majority of graduates take courses, of two years in some States and three years in others, in schools run for profit, many of them being schools having evening sessions only. A very small percentage is graduated from schools requiring a college degree for entrance, there being less than half a dozen such schools in the United States, and these have small classes. Eminent lawyers are endeavoring to have entrance requirements stiffened, with a view to eliminating competition. Less than half a dozen medical schools require the completion of a college education before entrance, and perhaps a dozen call for two years of college work after high school. A few years ago there were 176 medical schools in the United States, but last year only 116 were reported, the recent campaign against medical schools run for profit having resulted in good. Medical men, however, are divided on the question of too severe entrance requirements. Eminent physicians and surgeons give long lists of names of men who were instrumental in advancing medical knowledge, and would never have entered the medical profession had they been compelled to complete a 4 years' college course before studying medicine. It has been stated also that few discoveries of importance have been made by men not pressed by poverty, for the temptations to ease are hard to resist when men have the means to gratify their inclinations to loaf.

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* *Engineering News*, November 17th, 1910.

The argument is that only men backed by families of means can take a medical course if the entrance requirements are very severe. Mr. McCullough.

The movement to require longer preparation before studying law or medicine is inspired by the desire to cut down the number of practitioners. It is felt by some that, while this may eliminate a few good men, the resulting good to the profession in the improvement of the quality of the majority secured, will compensate for such possible loss. Opponents of the proposition point out that the loss possibly of another Jenner, or Harvey, or Lister is a large price to pay for securing an increased number of men fitted to shine socially, for the additional education required is not medical or surgical, but merely cultural, to the end that the members of the profession may make a good showing at "pink teas." Similar ideas prevail among men in the Engineering Profession. Some hope to have 6-year courses common, because, "there are too many engineers." Some wish to have two additional years for the purpose of enabling engineers to shine to better advantage socially. Some want a 4-year college course completed before beginning the study of engineering, for the same reason. At all events, it is seldom that the additional 2, 3, or 4 years are presumed to be spent on engineering subjects. It is pretty well settled that 3 or 4 years will suffice for the vocational studies connected with engineering, and the additional years are to be spent on the study of subjects of general interest. The writer proposes a re-adjustment of the curriculum, so that the general subjects may well come in the final years, the student being put at the vocational work as soon as possible.

Mr. Allen says "the schools will furnish that kind of education for which there is a strong demand from the students themselves." This is very pretty, but the truth is that few, if any, students entering engineering schools know what they need, still less what they want. Skilful advertising can make them believe they want anything the advertising department of the school presents for their attention. The students, that is, the undergraduates, should have nothing to say about what they want. Those who go in for vocational studies should get them. Those who can afford to wait until the completion of a college course can do so, but the fact remains that whatever road they take to obtain a degree in engineering, on graduation they must "hunt a job." The training offered at an engineering school should be such that the graduates will be enabled to fit in quickly, wherever employed. It is known that graduates of engineering schools may look confidently forward to salaried employment shortly after graduation, whereas graduates of law and medical schools generally contemplate going into business for themselves. Their training is of an eminently practical nature. The law schools have moot courts and also require a certain amount of time to be spent in court, in the search

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for precedents, and the study of famous cases in libraries. The lecturers are nearly all eminent attorneys who lecture on their specialties. Such lectures are not as technical as lectures of engineers and are usually a guide to the critical study of some text. Medical students begin early on dissection of bodies, and from the first attend clinics in the college and assist in operations. The lecturers in the medical schools are also surgeons and physicians of standing, whose lectures are expository and non-technical guides to the critical study of texts. Lawyers, physicians, and surgeons, as well as ministers of the Gospel (whose divinity schools are vocational schools of an extreme type) are considered to be well educated, cultured men because they mingle daily with people who are well read and cultured, and cannot fail to obtain a certain degree of polish. They also have plenty of time to do considerable reading of a general character, and can discuss intelligently the questions of the day.

Law and medical students are not ignorant of conditions to be encountered in the practice of their respective professions. They go valiantly into the fight for existence, hoping to succeed and willing to stay as long as they have any staying powers. Engineering students as a rule are inexpressibly shocked after graduation when they come face to face with conditions of employment and compensation. They believe, on entering school, that the Profession is most remunerative. They find after graduation that steady positions are the exception, and that pay does not invariably increase with years of experience and increased ability. They cannot go into private practice until near middle age and after the acquirement of considerable general experience. The variety of work performed by engineers during 20 years is remarkable when one makes a study of the lives of engineers, as shown by the biographies printed in the *Transactions* of this Society. Their training as engineers is received after leaving school. The training in school is to enable them to acquire quickly, and with certainty, much that they might acquire in a practical way in offices, with the expenditure of considerably more time and energy. That is, school training for engineers is an efficiency proposition, to enable them early to be of service to their employers and of value to themselves, to the end that they may sooner mount the lower steps on the ladder of success and be engaged on work of high grade while still young and full of energy—not yet discouraged and weary because of the hard battle of life. If the application of their studies to the practical problems of their life work is taught them early at school many will secure positions with the start given in the first one or two years in school and not remain to be graduated, while others will certainly stay to get more at school.

The writer is not opposed to embryo engineers remaining 10 years in school if they wish, nor to engineers stringing an alphabet of honors

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after their names, representing degrees conferred in course. He will gladly welcome the day when the general public looks on engineers as being at least as well educated as men belonging to what have heretofore been termed "the learned professions." In fact, he is not certain that the day has not arrived, for engineering at present is popularly supposed to be most desirable as a profession and business, the average man looking on engineers as men who have pursued a hard course of study in school, practical, but scientific. The writer, however, is opposed to the idea that all engineering students must receive their education in the same way, and in the same number of years, regardless of ability, or inherited, or acquired characteristics. The true engineer is a student all his life, the technical school giving him merely a start. We cannot compare methods in schools for other vocations with methods in engineering schools, for in law, medicine, and theology, one path in each must be followed, while engineering is a profession to which many distinct trades contribute.

Mr. Rogge well illustrates one point the writer might have brought out. The tendency among too many engineers is to magnify unduly the scientific and the clerical, or, as they term it, the technical, side of the work. Mr. Rogge saw that greater opportunities existed for him in getting into the business side of engineering, success following very quickly. He utilized his engineering education. It is more than likely that if he had spent several years more in school his sense of proportion would have been altered, and he would have stayed with the office instead of going out into the field as a business man.

The writer has a good friend, a consulting engineer of wide reputation, who is termed, by envious engineers, "a bluffer." There is not the slightest doubt that he would fail signally as an engineer, in the sense considered by the majority of the men contributing to this discussion, but, as an adviser on engineering matters, he is good. He was asked how he came to be so successful and said:

> "The school I attended treated me badly in the way of an education, and I figured after a couple of years' work that I was doomed to be a failure in the designing end, so I took a job as timekeeper and gradually worked up until I got into business for myself as a contractor. When I failed, and failed so big that my case attracted the attention of newspapers, I found myself in demand as a practical man to advise on big construction matters, and now I am a consulting engineer and making more money than any man in my class."

The writer knows another man who also failed to get at school what he had hoped for, but who, by self study, has finally acquired all that other men received in technical schools. His success has not been marked, because he looked too much on the clerical end of engineering as the main thing, instead of looking on his education as being merely preparatory to his entrance on life.

Mr. McCullough. Some time ago, the writer received a visit from a friend who lately resigned a position, in which he received a good salary, in order that he might go into private practice. He now regrets the action. On being asked why he left, he replied that his employers kept crowding so much of their general work on him that he had no time to attend to his engineering duties, and had to leave them to young assistants. He was disgusted at having to take up many legal points and at having to bother with contractors and their troubles. His idea of engineering was to design structures. The tendency is marked among men who put many years in school to assume just this attitude, and the logical place for such men is the school room as teachers, after they have obtained some practical experience. The writer believes, and has many times expressed in writing his belief, that an engineering course is the modern ideal in education, as opposed to the classical course. It will hurt no one to take such a course, provided he can always understand that every man who takes it should not do so with the idea of being a professional engineer. As a preliminary training for business life, it ranks with a legal education. The writer likes Mr. Rogge's discussion.

In regard to the remarks of Mr. Higgins, the writer feels it necessary again to call attention to the fact that he merely proposed a re-arrangement of the curricula of technical schools so that boys with low ideals might sooner be fit to leave and go to work. Let each student feel each year that he is a little better prepared to earn a living, and if he stops going to school before he has done all the work required for a degree, he may be doing the best thing for himself and the best thing for the Profession. When the ups and downs of engineers are as well known to the general public as are the trials and tribulations of lawyers, medical men, and ministers, so that all young men who go to engineering schools face their future with wide open eyes, such discussions as this will be out of date. The writer distinctly referred to the fact that his paper is intended to deal with the technical schools of the present day, not the university engineering schools of the future, when what is exceptional knowledge now will then be common knowledge. It is fascinating to think of what our great-grandchildren may have to master before they will be considered fit to practice a profession, or even earn a living.

Whatever Professor Swain writes is good to read, and the writer is flattered that he took time to discuss the paper. The writer does not by any means consider it a bad thing that men educated in technical schools often turn to other lines of work, and regrets that it was possible for any one reading his paper to get that impression. He does regret that the courses of study are arranged so that students seldom get to the practical side of their work until the last couple of years, this forcing them to stay in the Profession merely be-

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cause they feel that their long training would be wasted. Parents who pay the bills always feel that way, so the courses of study might be arranged to give the young men practical training from the start. It has been asked what specifications an engineer might propose. They have been pretty well stated by Professor Swain: "He wants a man who is faithful, who is of good character, conscientious, who can think straight, who will not be anxious to stop work as soon as the bell rings, who will be loyal to his employer, who has 'gumption,' and who can meet emergencies." He might add that the school should also take considerable pains to make the students understand the actual conditions attached to engineering employment and the compensation therefor, the importance of living on half the pay when earning, to understand that employers have nothing against young graduates as such, but because few of them are worth their small pay for several months after leaving school, some not for a year or more. Employers also want men skilled in common arithmetical computation and with the ability to make neat drawings and do decent lettering; these, in addition to all the qualities of manhood mentioned by Professor Swain and necessary as well in other lines of business. Young men are not intrusted with important work, so their education should fit them to do well the small and comparatively unimportant things their employers put them at. A careful reader of the paper should see that the writer lays considerable stress on the studies enabling men to mix well with the world.

A high standard for the Engineering Profession is very well, and the writer is as keen for it as any engineer, but the paper he presented was from the point of view of the more than 90% of students who take engineering courses for their purely vocational, and not for their cultural, value. These green young men and boys enter a school to study engineering with the intention of earning a living at engineering work, and do not know what it implies or what the real opportunities are. At the end of the freshman year they must select some specialty, still ignorant, for the freshman year is merely an extension of high school and there is seemingly no tie in it to the life of an engineer. A month ago a young man called on the writer for advice as to his future. He entered a State university for a college course and met a boy who persuaded him to enter the college of engineering. This was the first time he knew that engineering did not necessarily mean the running of an engine. He remarked that he could see little difference between the freshman work and the senior year in high school, and drifted along unthinkingly until spring when he was suddenly made aware of the fact that the university gave eleven distinct engineering courses, and he must make a selection of a specialty. He still knew no more about the calling of the engineer than he did on leaving high school. His parents could not help

Mr. McCullough. him, but his indecision was settled by a series of social events of the eleven engineering societies, who were engaged in "rushing" freshmen. The mining society gave what he called the "swellest" reception and entertainment and had the best floats in the annual college parade. The career of John Hays Hammond was at that time attracting considerable newspaper and magazine attention, so the boy entered the mining school. This may sound far fetched, but he states as a fact that he took the sophomore and junior work in the mining department without seeing a mine. A requirement of the school is that students must spend not less than 3 months in some vacation in actual mining work, in order to be eligible to enter the senior class and obtain the degree in mining. In his first vacation he helped the county surveyor near home. In the second vacation he was a draftsman in the office of a structural engineer. This past summer he had to do mining work or be unable to register this fall as a senior, so he went into a mining district to seek employment. He worked for 3 months, but to the last day was unable to rid himself of a disagreeable feeling in the pit of his stomach when going down a shaft. He was always impressed with a feeling of insecurity when in the workings, and the number of accidents he witnessed were not reassuring. On top of the ground he is all right, but he hates to think of spending his life in mines. He was advised to complete his course of study and get rid of the feeling that since he studied mining engineering he must of necessity follow that as a profession. His training in surveying, drafting, mathematics, physics, and chemistry will enable him to be a good assistant in the office of an engineer or manufacturer, which, after all, is the most that a technical school should expect to give, the technical school, it must be remembered, being something different from a high-grade engineering school attached to a university and headed by men like Professor Swain.

Professor Swain says: "It is impossible for a man who has not tried to teach to draw up a curriculum which will work well; he almost always forgets that the problem of engineering education, or of education in general, is not an engineering problem, but a human problem." The writer begs to state that he has not only tried to teach, but is rated as a successful teacher. He has taken classes abandoned by professional teachers, and greatly increased them in number because he understood the men with whom he was dealing, their problems encountered in trying to earn a living, their object in studying at night after working all day, the best methods of handling them so as to inspire interest in the subject and hold it to the completion of the work. He has also been successful in coaching young men unable to follow intelligently their paid teachers in college and technical schools, boys who would otherwise have been "flunkers." In his paper he endeavored to deal with the problem of engineering education as a human problem, the sub-

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ject being discussed as a vocational, and not a purely educational proposition. He has tried to suggest that the instruction be imparted somewhat more practically in the first two years, in a human and humane manner. The writer must remind Professor Swain, as he has other men who have presented discussions, that he has merely changed the order of studies and not proposed a brand new curriculum.

In reply to Messrs. Fuller and Buerger, the writer must call their attention—as he has called the attention of others preceding them in the discussion—to the paper. He fails to find anything in it to lead any one to believe that he advocates a narrow training or that he decries education of the proper kind. He simply attempts to rearrange the curriculum, omitting nothing of value, adding much of value, and postponing to the reasoning years subjects deemed "cultural"; leaving the study of economics, history, literature, sociology, etc., to minds capable of reasoning.

Teachers uniformly resent suggestions from practicing engineers and from employers of engineering graduates, claiming that such suggestions have a narrowing tendency, and that men not teachers do not put the proper "cultural" value of education to the front. This is not borne out by the facts. A study of discussions on engineering education, from the time such discussions commenced, will show that the practicing engineer has been more instrumental than the teaching engineer in having more attention paid to general subjects. The practicing engineer laughs at the long array of specialities listed in catalogues of engineering schools, and knows, as the result of actual experience in winning a living, that a few fundamental things well taught are sufficient; but they must be well taught. The teachers, each one anxious to magnify his importance in the faculty and gain glory and higher pay, are the men responsible for the narrowing of the curriculum. Teachers, by pushing special courses, which the bewildered freshman must consider, stultify their remarks about general education and the cultural value of education. Professor Fuller says:

> "In talking with some of his own students the speaker has noticed a greater inclination to take general work in the latter part of the curriculum than in the first. If given in the first part, it is thrust upon them; if available later, many will take it willingly. The speaker has heard practicing engineers suggest such an arrangement."

If this be so, then why not try it?

Without wishing to appear to be a critic of teachers, for he also teaches, because he likes it and teaches a class of men who come voluntarily to get the work, the writer must say that no class of men is less tolerant of suggestion and apparent criticism, than teachers, beginning with the kindergarten grade. This is for the reason that teaching is a vast organized profession, fettered with precedent and

Mr. McCullough. hampered by tradition. These remarks must be softened by the statement, that with all the criticism of the teaching class indulged in by people who must employ the product turned out of institutions of learning, the greatest changes and improvements in teaching methods have come from the ranks of the teachers. However, there is a deadening influence at work tending to weaken those who teach continuously many years. For this reason, the writer is greatly in favor of teachers in technical schools being employed on practical work, and thinks there should be a greater amount of practical work demanded of them. Good teachers should be given leave of absence at stated times, under full pay, so that they may go into the ranks of engineers, to the end that the deadly monotony, inherent in all large organizations and classes, shall not stunt their minds.

Professor Fuller asks, with others, for a specification for the preparation of engineers' assistants. It has been given already in this closure, as well as in the paper. The writer nowhere stated, nor did he imply, that the product of the "engineer factories" should be guaranteed, as some of the gentlemen who have discussed the paper facetiously remarked. A reference again to the paper is suggested. The reason for asking that the wishes of the employer be more carefully considered has been sufficiently dealt with in the paper and in this closure.

The writer agrees with Mr. Buerger that the best training is the most broad, and that a division into specialties is to be deplored, as far as undergraduates are concerned. Employers, however, are not willing to give all the practical training so essential. There are too many thousands of graduates turned out annually from technical schools to compel the employer to waste much time with the unfit and incompletely trained. A three-line advertisement in the Sunday edition of any good daily paper will suffice to fill the mail box to overflowing with applications for work. Short shrift is given those who do not take hold quickly. Many who might otherwise have been successful are doomed to wander for many years from job to job, because of the false view of life obtained in the institutions supposed to be created for the purpose of supplying the demand of the industrial world for trained workers. The technical school is assumed to exist for a particular purpose, and it does not fulfill its mission if the majority of graduates fail to meet with as much success as the average man.

The writer endorses most heartily all that Mr. Buerger says, beginning with the words, "The ordinary school lecture is an abomination," and continuing to the end of his discussion, which should be taken to heart by every teacher, every practicing engineer, and every employer of the product of engineering schools. Make the boys work hard from the start. Teach a smaller number of subjects at one time if necessary, to carry out the ideas expressed in his two sentences relating to methods of teaching. The employment of older students to assist the teacher is excellent, as the writer has found in his own teaching experience, for it helps every one. A man learns best when he has to teach, and the student is inspired when he works with his teacher, instead of trying to do what he is told to do, with occasional guidance from one who assumes a superior attitude. Mr. McCullough.

A fitting end to this discussion is the following:*

"*Educating the Educators.*—The University of Cincinnati was one of the first in this country to apply continuation school methods—giving a pupil shop practice under actual commercial conditions, along with textual instruction. Dean Schneider, of the engineering college, has made some interesting confessions of the reflex action upon the university faculty of this practical shop training. He says:

"'We learned the first year, and have had it verified each year since, that the shop will spot a yellow streak in a man before the university even suspects it. An attempt to sneak through spoiled work is never a great success there. We, at the college end, soon found our work under scrutiny and criticism from a source that does not hesitate to scrutinize and criticise. We are brought face to face with the failure of a university department as we never are in our four-year courses. A student, let us say, has finished successfully his work in physics. Some day he does a fool thing in the shop which indicates that he knows very little about the subject. When you confront him with the fool thing, and with the fact that he should have known better because he had been taught the theory governing it, you find his grasp upon the theory to be very feeble.'

"Practical education will teach the teachers. We imagine it would not be a bad thing in every university if pupils and instructors, pleasantly loafing through their four-year literary courses, were periodically checked up by some hard-and-fast test drawn from actual life outside the campus, whereby they could discover exactly how efficient their processes were."

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* Editorial from *The Saturday Evening Post*, October 5th, 1912.

MEMOIRS OF DECEASED MEMBERS.

NOTE.—Memoirs will be reproduced in the volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

ALFRED ELLSWORTH CARTER, M. Am. Soc. C. E.*

DIED JUNE 11TH, 1912.

Alfred Ellsworth Carter was born at Blair, Nebr., on April 19th, 1867, of American parents, his ancestry dating back through several generations of pioneer stock. His early education was obtained at the public schools of his home town, and, later, at the University of Nebraska, from which he received the degree of Bachelor of Science, in 1900. In 1902 he entered Columbia University, New York City, and was graduated in 1904 with the degree of Civil Engineer.

Mr. Carter's early experience was gained while earning his way through college. In the the early Nineties he was in the employ of the Chicago and Northwestern Railway Company, in Fremont, Elkhorn and Missouri Valley Railroad activities, holding successively the positions of Chainman, Rodman, and Transitman, on miscellaneous surveys in Nebraska and the Black Hills of South Dakota. From August, 1897, to March, 1899, he was Assistant Engineer on the construction of a hydro-electric power dam at Divide, Mont., an impounding reservoir dam adjacent to Butte, Mont., and one of the first wood stave and riveted steel pipe lines for the Montana Power Company.

Following the Spanish-American War, from October, 1900, to October, 1902, Mr. Carter was Assistant Engineer in charge of detailed designing of sewers and pumping stations for two sections of the marginal sewer system of Havana, Cuba, being associated with Samuel M. Gray, M. Am. Soc. C. E., Consulting Engineer, the work being done by the Department of Sewers, under Military Government, William M. Black, M. Am. Soc. C. E., Colonel, Corps of Engineers, U. S. A., being in general charge at Havana.

From January, 1905, to the time of his death, Mr. Carter was in the employ of the Rapid Transit Subway Construction Company, Contractors, of New York City, as Assistant Engineer, until 1908, in charge of tunnel alignment, check surveys, track-laying, and driving reinforced concrete piles, on the construction of the East River Tunnel of the Rapid Transit Railroad; then Resident Engineer in charge of construction of the Bowling Green Shuttle Station, and the Subway station extensions at the Fulton Street, Wall Street, Bowling Green, Borough Hall, and Atlantic Avenue Stations of the Interborough

---

* Memoir prepared by George H. Pegram, M. Am. Soc. C. E.

Rapid Transit Company. He was also engaged in reporting on extra claims of the Sub-contractor on the East River Tunnel.

At the time Mr. Carter became engaged on the work of the East River Tunnel, the Brooklyn tubes were just entering the river section and the Manhattan tubes had not emerged from the rock. He was employed continuously on this work until its completion in January, 1908. It has been described as one of the most difficult pieces of engineering work ever accomplished. Mr. Carter's position as Assistant Engineer imposed great responsibilities on him. He was in charge of the delicate operations of sinking piles through the bottom of the tubes to rock. The character of the work and the financial failure of the Sub-contractor, during the construction of the tunnel, made the accounting unusually complicated. The patience and fidelity with which Mr. Carter worked in checking the claims of the Sub-contractor and the skill and judgment evinced in his reports are remarkable. It was a work of great labor and uncongenial to an Engineer, but his familiarity with the construction forced it on him. His engineering work had been above criticism, but this work was almost above praise.

Subsequently, Mr. Carter was put in charge, as Resident Engineer, of the construction of Bowling Green Shuttle Station and the lengthening of the Subway stations from Fulton Street, Manhattan, to Atlantic Avenue, Brooklyn. Like his East River Tunnel experience, this work was of the most difficult character. The continuous operation of trains, the congested street traffic, the numerous sub-surface structures which interfered with the work, such as sewers, water pipes, electric subways, and the foundations of buildings, made it always a delicate task.

The work of extending the Borough Hall Station in Brooklyn, for which Mr. Carter designed the shoring and directed the work for the Construction Company, was especially difficult. This station was built of reinforced concrete which was exceptionally difficult to remove. At this point there are three tracks in the Subway, with cross-overs, and on the surface of the street there is a junction of two tracks in Court Street and two tracks in Fulton Street. Both side-walls of the Subway, for a length of 135 ft., were entirely removed, and its roof with 7 ft. of cover, together with street structures, etc., was supported on timber. Three columns of the Elevated Railroad in Brooklyn were temporarily supported over the work and the foundations renewed; the cast-iron pipes and the gate-chambers of the high-pressure water mains were supported and reconstructed at an especial menace to the work. In addition, the portico of the County Court House, weighing more than 1 000 tons, a structure with four large granite columns, thus having little transverse stiffness, was temporarily supported, and the foundations were carried 12 ft. deeper by masonry underpinning. This was done without the slightest show of crack or any measurable settlement of the portico. All this work was in sand and Mr. Carter was continually obliged to render it safe against the breakage of water pipes or the unusual flood of storm-water.

This work was about completed at the time of his death, which occurred suddenly at his home in New York City on June 11th, 1912, from cerebral hemorrhage.

Mr. Carter was a man of sterling integrity, with the ability for doing hard work well, and accepting and fulfilling growing responsibilities with quietness and efficiency; the consideration he gave to all matters, large or small, entrusted to his care, had won for him the respect of his associates and those who worked under his direction.

In 1904 Mr. Carter was married to Miss Ida C. Messer, of Cleveland, Ohio, who survives him. She is a lady of unusual educational attainments and was able to assist him in his professional work.

He was a Member of Columbia Chapter (Kappa) of the Society of the Sigma Xi, and a Member of Washington Lodge No. 21, F. & A. M., of Blair, Nebr.

Mr. Carter was elected an Associate Member of the American Society of Civil Engineers, on June 4th, 1902, and a Member on April 4th, 1911.

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William P. Morse

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

VOL. XXXVIII—No. 9

PRESENTED TO
N. Y. CIVIL
ENGINEERING SOCIETY
BY
WILLIAM P. MORSE

AMERICAN
SOCIETY OF
CIVIL
ENGINEERS
FOUNDED
1852

November, 1912

Published at the House of the Society, 220 West Fifty-seventh Street, New York, the Fourth Wednesday of each Month, except June and July.

Copyrighted 1912, by the American Society of Civil Engineers.
Entered as Second-Class Matter at the New York City Post Office, December 15th, 1896.
Subscription, $8 per annum.

PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

(INSTITUTED 1852)

VOL. XXXVIII—No. 9
NOVEMBER, 1912

Edited by the Secretary, under the direction of the Committee on Publications.

Reprints from this publication, which is copyrighted, may be made on condition that the full title of Paper, name of Author, page reference, and date of presentation to the Society, are given.

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Vol. XXXVIII. NOVEMBER, 1912. No. 9.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PROCEEDINGS

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MINUTES OF MEETINGS

OF THE SOCIETY

October 16th, 1912.—The meeting was called to order at 8.30 P. M.; William E. Belknap, Director, in the chair; Chas. Warren Hunt, Secretary; and present, also, 99 members and 9 guests.

A paper by A. C. Polk, Assoc. M. Am. Soc. C. E., entitled "A Brief Description of a Modern Street Railway Track Construction," was presented by the Secretary, who also read communications on the subject from Messrs. E. E. R. Tratman and Walter C. Howe. The paper was discussed orally by Messrs. W. J. Boucher and E. W. Lewis.

A paper by P. A. Beatty, M. Am. Soc. C. E., entitled "Construction of a High-Service Reservoir at Baltimore, Md.," was also presented by the Secretary.

The Secretary announced the following deaths:

James Hugh Wise, elected Associate Member, February 6th, 1907; died September 16th, 1912.

Stephen Holman, elected Fellow, June 29th, 1872; died October 13th, 1912.

Adjourned.

November 6th, 1912.—The meeting was called to order at 8.30 P. M.; Director T. Kennard Thomson in the chair; Chas. Warren Hunt, Secretary; and present, also, 98 members and 10 guests.

The minutes of the meetings of September 18th and October 2d, 1912, were approved as printed in *Proceedings* for October, 1912.

The following resolution was presented by the Secretary in behalf of Robert A. Cummings, M. Am. Soc. C. E.:

"*Resolved:* That a Special Committee of seven be appointed by the Board of Direction to codify present practice on the bearing value of soils for foundations, and report upon the physical characteristics of soils in their relations to engineering structures."

The resolution, being duly seconded, was adopted and referred to the Board of Direction by a vote of more than 25 Corporate Members.

Kenneth C. Grant, Assoc. M. Am. Soc. C. E., presented a paper entitled "The Flood of March 22d, 1912, at Pittsburgh, Pa." The Secretary read communications on the subject from Messrs. L. J. Le Conte and William R. Copeland, and the paper was further discussed by Messrs. Jean de Pulligny, L. D. Rights, J. Waldo Smith, William R. Copeland, Morris Knowles, and the author.

A paper entitled "State and National Water Laws, with Detailed Statement of the Oregon System of Water Titles," by John H. Lewis, Assoc. M. Am. Soc. C. E., was presented by title. The Secretary read communications on the subject from Messrs. George L. Dillman, L. J. Le Conte, W. E. Moore, Clarence T. Johnston, Morris Bien, and Horace W. Sheley, and the paper was discussed orally by Messrs. Morris Knowles and Kenneth C. Grant.

The Secretary announced the establishment of two additional prizes: The J. James R. Croes Medal and the James Laurie Prize.*

The Secretary announced that the Forty-fifth Annual Convention of the Society will be held at Ottawa, Ont., Canada.

The Secretary announced the election of the following candidates on October 29th, 1912:

As Members

Dan John Albertson, Kalamazoo, Mich.
Horace Holmes Chase, Brockton, Mass.
David Gutman, New York City
Horace Theophilus Herrick, Keokuk, Iowa

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* For details, see page 616.

Frederick Spencer Janes, Appleton, Wis.
George Mattis, San Luis Obispo, Cal.
Joseph Ogier Whittemore, Hoboken, N. J.
George David Williams, Goshen, N. Y.

As Associate Members

Carl Bowers Andrews, Honolulu, Hawaii
Ora Grover Baxter, Little Rock, Ark.
George Ray Boyd, Wilson, N. C.
Joseph Charles Boyd, Sacramento, Cal.
Olaf John Sverdrop Ellingson, Sherman, Tex.
Waveland Sinclair Fitzsimons, Georgetown, S. C.
Ingwald Edward Flaa, San Francisco, Cal.
Walter Whitfield George, New Philadelphia, Ohio
Clinton Raymond Goodrich, Houston, Tex.
Joseph Vincent Hogan, Medina, N. Y.
Clifford Milburn Holland, Brooklyn, N. Y.
Raleigh Hortenstine, Dallas, Tex.
Paul Henry Keppel, Sagua la Grande, Cuba
Angus Robert Mackay, Wickenburg, Ariz.
Grover John Meyer, Sultan, Wash.
Manley Peroe Northam, St. George, N. Y.
Harold Coe Ogden, Holly, Colo.
George Alfred Peabody, Cleveland, Ohio
Tracy Irwin Phelps, Thistle, Utah
Francis Benjamin Plant, San Francisco, Cal.
Curtis Charles Saner, Evanston, Ill.
Henry Andrew Sherman, Sault Ste. Marie, Mich.
Fred Charles Smith, Sioux City, Iowa
Ira Otis Thorley, Denver, Colo.
William Horace Williams, New Orleans, La.

As Associate

Frederick Hugh Parry, Kingston, Pa.

As Juniors

Albert Asa Baker, Brooklyn, N. Y.
George Allyne Belden, Upper Montclair, N. J.
Francis Clarence Boerner, New York City
Joseph Dydeme Guillemette, Wilkinsburg, Pa.
Alvin Arthur Horwege, San Francisco, Cal.
Hugh Ambrose Kelly, Jersey City, N. J.
Murtland Kincaid, New York City
Charles Scott Patterson, Waco, Tex.
Frederick Williams, New London, Conn.
Mark Stevens Woodin, Olympia, Wash.

The Secretary announced the transfer of the following candidates on October 29th, 1912:

FROM ASSOCIATE MEMBER TO MEMBER

ALGERNON BROWN ALDERSON, Hartford, Conn.
ARTHUR BENJAMIN FARNHAM, Pittsfield, Mass.
NORMAN ROOSEVELT MCLURE, Phœnixville, Pa.
CHARLES ANDREW POHL, New York City
AUGUSTUS VALENTINE SAPH, Berkeley, Cal.

FROM JUNIOR TO ASSOCIATE MEMBER

LOWREY WALLACE ANDERSON, Pecos, Tex.
JAMES RAMSEY BALDRIDGE, New York City
WILLIAM JOSHUA BARNEY, New York City
DAVID HARELL BROWN, Yonkers, N. Y.
EDWIN LEROY DRIGGS, Manila, Philippine Islands
HOWARD KINGSBURY HOLLAND, Ann Arbor, Mich.
HOPE RICHARD MESSER, Richmond, Va.
OSWALD PROCTER SHELLEY, San Francisco, Cal.
CHARLES EDWARD STILSON, Fairfax, N. C.
ASAHEL CLARK TOLL, Bayamon, Porto Rico
WILLIAM HAROLD WARNOCK, New York City

The Secretary announced the following deaths:

CARL WALDEMAR BUCHHOLZ, elected Member, September 1st, 1886; died October 20th, 1912.

EDWARD MOHUN, elected Member, April 6th, 1892; died October 23d, 1912.

HENRY FISHER WHITE, elected Member, January 2d, 1890; date of death unknown.

Adjourned.

OF THE BOARD OF DIRECTION

(Abstract)

October 29th, 1912.—President Ockerson in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Belknap, Bush, Churchill, Clarke, Endicott, Gerber, Kimball, Knap, Loomis, Ridgway, Snow, Staniford, Strobel, and Thomson.

The following resolution was adopted:

"*Resolved:* That hereafter mileage shall be paid to each member of the Nominating Committee who attends the one annual meeting of that Committee at the place determined upon by its members, in accordance with and as prescribed in the Constitution, at the rate of three cents per mile each way by the shortest practicable route from the place of residence of such members to place of meeting, when said meeting is held within Continental North America."

It was determined that the next Annual Convention of the Society be held at Ottawa, Ont., Canada.

The following resolutions were adopted:

"*Resolved:* That it is the sense of the Board of Direction that it is advisable to hold each year one or more of the regular meetings of the Society other than the Annual Convention away from Headquarters."

"*Resolved:* That the mid-month meeting of October, 1913, be held in New Orleans, La."

Special Meetings of the Society for the discussion of Construction and Maintenance of Roads and Pavements on Friday and Saturday, January 17th and 18th, 1913, were authorized.

Ballots for membership were canvassed, resulting in the election of 8 Members, 25 Associate Members, 1 Associate, and 10 Juniors, and the transfer of 11 Juniors to the grade of Associate Member.

Five Associate Members were transferred to the grade of Member.

Applications were considered and other routine business transacted.

Adjourned.

ANNOUNCEMENTS

The House of the Society is open from 9 A. M. to 10 P. M., every day, except Sundays, Fourth of July, Thanksgiving Day, and Christmas Day.

FUTURE MEETINGS

December 4th, 1912.—8.30 P. M.—This will be a regular business meeting. Two papers will be presented for discussion, as follows: "Tufa Cement, as Manufactured and Used on the Los Angeles Aqueduct," by J. B. Lippincott, M. Am. Soc. C. E.; and "The Economic Aspect of Seepage and other Losses in Irrigation Systems," by E. G. Hopson, M. Am. Soc. C. E.

These papers were printed in *Proceedings* for October, 1912.

December 18th, 1912.—8.30 P. M.—At this meeting two papers will be presented for discussion, as follows: "Prevention of Mosquito Breeding," by Spencer Miller, M. Am. Soc. C. E.; and "The Sanitation of Construction Camps," by Harold Farnsworth Gray, Jun. Am. Soc. C. E.

These papers are published in this number of *Proceedings.*

January 1st, 1913.—8.30 P. M.—A regular business meeting will be held, and a paper by H. T. Cory, M. Am. Soc. C. E., entitled "Irrigation and River Control in the Colorado River Delta," will be presented for discussion.

This paper is printed in this number of *Proceedings.*

ANNUAL MEETING

The Sixtieth Annual Meeting will be held at the Society House, on Wednesday and Thursday, January 15th and 16th, 1913. The Business Meeting will be called to order at 10 o'clock on Wednesday morning. The Annual Reports will be presented, officers for the ensuing year elected, members of the Nominating Committee appointed, Reports of Special Committees presented for discussion, and other business transacted.

SPECIAL MEETINGS FOR TOPICAL DISCUSSION

Meetings for the discussion of "Road Construction and Maintenance" will be held on Friday and Saturday, January 17th and 18th, 1913 (the days following the close of the Annual Meeting of the Society).

As soon as arrangements are completed, the hours for holding these meetings, topics for discussion, names of speakers, etc., will be published.

ADDITIONAL MEDAL AND PRIZE

At the present time there are two prizes which may be awarded annually for papers published in the *Transactions* of the Society. They are the Norman Medal, which was instituted and endowed in 1873 by the late George H. Norman, M. Am. Soc. C. E.; the Thomas Fitch Rowland Prize, instituted by the Society at the Annual Meeting of 1882, and subsequently endowed in 1884 by the late Thomas Fitch Rowland, Hon. M. Am. Soc. C. E.; and the Collingwood Prize for Juniors, instituted and endowed by the late Francis Collingwood, M. Am. Soc. C. E. The rules governing the award of these prizes will be found in the List of Members for 1912, page 24.

Thirty-four awards of the Norman Medal, twenty-nine awards of the Thomas Fitch Rowland Prize, and eleven awards of the Collingwood Prize for Juniors, have been made to date.

For some time the Board of Direction has had under consideration the advisability of the establishment of one or more additional prizes. It has several times happened that it has been difficult for the Committee to decide which of two papers was entitled to one of the prizes, and there has been a great increase in the number of papers published annually.

In the establishment of these additional prizes, it was the idea of the Board that they should be so arranged as not to detract in any way from the value or desirability of the prizes which have been so long in existence.

It was therefore decided to establish an additional medal to be awarded each year, which will be secondary to the Norman Medal, and one prize which will be secondary to the Thomas Fitch Rowland Prize. The first of these will be known as the "J. James R. Croes Medal," in honor of the first recipient of the Norman Medal, and the second will be known as the "James Laurie Prize," in honor of the first President of the Society.

Owing to an error, the action covering the establishment of these prizes by the Board of Direction at its meeting of October 1st, 1912, was omitted from the minutes as printed, and the resolutions are therefore reproduced here for the information of the membership.

RESOLUTIONS ADOPTED BY THE BOARD OF DIRECTION, OCTOBER 1ST, 1912:

"Resolved: That this Society shall and it does hereby institute two prizes for papers published in the *Transactions* of the American Society of Civil Engineers, to be awarded annually beginning with the papers published in the *Transactions* during the year ending July 31st, 1913, as follows: One of such prizes to be a medal, of the value of $40, to be known as the J. James R. Croes Medal, in honor of the first recipient of the Norman Medal, and may be awarded in any year, under the rules governing the award of the Norman Medal, to such paper as may be judged to be worthy of the award and to be next in order of merit to the paper to which the Norman Medal is awarded, or, if the Norman Medal is not awarded, then to a paper, if any, which shall be judged worthy of the award of this prize for its merit as a contribution to engineering science.

"The other of such prizes to consist of $40 in cash, with an engraved certificate signed by the President and Secretary of the Society, to be known as the James Laurie Prize, in honor of the first President of the Society, and to be awarded under the rules governing the award of the Thomas Fitch Rowland Prize to such paper as may be judged to be worthy of the award and to be next in order of merit to the paper to which the Thomas Fitch Rowland Prize is awarded, or, if the Thomas Fitch Rowland Prize is not awarded, then to a paper, if any, which shall be judged worthy of the award of this prize for its merit as a contribution to engineering science, and, be it further

"*Resolved:* That the Secretary and Treasurer of the Society be and they are hereby authorized to pay annually out of the funds of the Society such amounts as may be necessary to cover the award of the prizes hereby instituted."

SEARCHES IN THE LIBRARY

In January, 1902, the Secretary was authorized to make searches in the Library, upon request, and to charge therefor the actual cost to the Society for the extra work required. Since that time many searches have been made, and bibliographies and other information on special subjects furnished.

The resulting satisfaction, to the members who have made use of the resources of the Society in this manner, has been expressed frequently, and leaves little doubt that, if it were generally known to the membership that such work would be undertaken, many would avail themselves of it.

The cost is trifling compared with the value of the time of an engineer who looks up such matters himself, and the work can be performed quite as well, and much more quickly, by persons familiar with the Library.

In asking that such work be undertaken, members should specify clearly the subject to be covered, and whether references to general books only are desired, or whether a complete bibliography, involving search through periodical literature, is desired.

In reference to this work, the Appendices* to the Annual Reports of the Board of Direction for the years ending December 31st, 1906, and December 31st, 1910, contain summaries of all searches made to date.

PAPERS AND DISCUSSIONS

Members and others who take part in the oral discussions of the papers presented are urged to revise their remarks promptly. Written communications from those who cannot attend the meetings should be sent in at the earliest possible date after the issue of a paper in *Proceedings*.

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* *Proceedings*, Vol. XXXIII, p. 20 (January, 1907); Vol. XXXVII, p. 28 (January, 1911).

All papers accepted by the Publication Committee are classified by the Committee with respect to their availability for discussion at meetings.

Papers which, from their general nature, appear to be of a character suitable for oral discussion, will be published as heretofore in *Proceedings,* and set down for presentation to a future meeting of the Society, and, on these oral discussions, as well as written communications, will be solicited.

All papers which do not come under this heading, that is to say, those which from their mathematical or technical nature, in the opinion of the Committee, are not adapted to oral discussion, will not be scheduled for presentation to any meeting. Such papers will be published in *Proceedings* in the same manner as those which are to be presented at meetings, but written discussions, only, will be requested for subsequent publication in *Proceedings* and with the paper in the volumes of *Transactions.*

LOCAL ASSOCIATIONS OF MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Association

The San Francisco Association of Members of the American Society of Civil Engineers holds regular bi-monthly meetings, with banquet, and weekly informal luncheons. The former are held at 6 P. M., at the Palace Hotel on the third Friday of February, April, June, August, October, and December, the last being the Annual Meeting of the Association.

Informal luncheons are held at 12.15 P. M. every Wednesday, and the place of meeting may be ascertained by communicating with the Secretary of the Association, E. T. Thurston, Jr., M. Am. Soc. C. E., 713 Mechanics' Institute, 57 Post Street.

The by-laws of the Association provide for the extension of hospitality to any member of the Society who may be temporarily in San Francisco, and any such member will be gladly welcomed as a guest.

(Abstract of Minutes of Meetings)

August 21st, 1912.—The meeting was called to order; President Grunsky in the chair; E. T. Thurston, Jr., Secretary; and present, also, 68 members and 4 guests.

An invitation from the Pacific Coast Steel Company to visit its new steel plant was accepted.*

Messrs. Bogue and Martin addressed the meeting, the latter giving an extended and comprehensive description of engineering problems and progress in the Hawaiian Islands.

A. H. Markwart, Assoc. M. Am. Soc. C. E., read a paper on "The Design and Construction of the New Swing Bridge of the Northern

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* This visit was made on August 30th, 1912, when about forty persons were the guests of the Company.

Electric Railway Company, Across the Sacramento River at M Street, Sacramento, Cal.," illustrating his remarks with stereopticon views. The subject was discussed by Messrs. J. D. Galloway, A. L. Bobbs, H. J. Brunnier, C. E. Grunsky, S. A. Jubb, J. B. Leonard, and F. H. Tibbetts.

Adjourned.

October 18th, 1912.—The meeting was called to order; President Grunsky in the chair; E. T. Thurston, Jr., Secretary; and present, also, 57 members and guests.

The reports of the Committees appointed to prepare obituary notices and resolutions of sympathy in memory of the late James Dix Schuyler, M. Am. Soc. C. E., and James Hugh Wise, Assoc. M. Am. Soc. C. E., were read by President Grunsky. The resolutions and obituary notices were ordered spread on the minutes of the Association and copies of the resolutions sent to Mrs. Schuyler and Mrs. Wise, respectively.

President Grunsky read a communication from Charles Derleth, Jr., M. Am. Soc. C. E., Secretary of the Pacific Association of Consulting Engineers, in regard to action on the proposed amendment to the California Code of Civil Procedure, looking to improvement in the method of selecting experts as witnesses in cases requiring professional and technical knowledge. After discussion, the amendment was ordered printed and distributed to the members of the Association, with a request for suggestions and expressions for or against, the result to be transmitted to the Pacific Association of Consulting Engineers.

W. C. Hammatt, M. Am. Soc. C. E., addressed the meeting on the proposed system of public roads to be constructed in connection with the development of the Hetch-Hetchy water system for San Francisco, illustrating his remarks with stereopticon views.

Adjourned.

Colorado Association

The meetings of the Colorado Association of Members of the American Society of Civil Engineers are held on the second Saturday of each month, except July and August. The hour and place of meeting are not fixed, but this information will be furnished on application to the Secretary, Gavin N. Houston, M. Am. Soc. C. E., 409 Equitable Building, Denver, Colo. The meetings are usually preceded by an informal dinner. Members of the American Society of Civil Engineers will be welcomed at these meetings.

Weekly luncheons are held on Wednesdays, and, until further notice, will take place at the Colorado Traffic Club.

Visiting members are urged to attend the meetings and luncheons.

Atlanta Association

On March 14th, 1912, the Atlanta Association of Members of the American Society of Civil Engineers was organized, with the following officers: Arthur Pew, President; William A. Hansell, Jr., Secretary; and Messrs. James N. Hazlehurst and Alexander Bonnyman, Members of the Executive Committee. The Association will hold its meetings in the house of the University Club.

PRIVILEGES OF ENGINEERING SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Members of the American Society of Civil Engineers will be welcomed by the following Engineering Societies, both to the use of their Reading Rooms and at all meetings:

American Institute of Mining Engineers, 29 West Thirty-ninth Street, New York City.

American Society of Mechanical Engineers, 29 West Thirty-ninth Street, New York City.

Architekten-Verein zu Berlin, Wilhelmstrasse 92, Berlin W. 66, Germany.

Associação dos Engenheiros Civis Portuguezes, Lisbon, Portugal.

Australasian Institute of Mining Engineers, Melbourne, Victoria, Australia.

Boston Society of Civil Engineers, 715 Tremont Temple, Boston, Mass.

Brooklyn Engineers' Club, 117 Remsen Street, Brooklyn, N. Y.

Canadian Society of Civil Engineers, 413 Dorchester Street, West, Montreal, Que., Canada.

Civil Engineers' Society of St. Paul, St. Paul, Minn.

Cleveland Engineering Society, Chamber of Commerce Building, Cleveland, Ohio.

Cleveland Institute of Engineers, Middlesbrough, England.

Dansk Ingeniorforening, Amaliegade 38, Copenhagen, Denmark.

Engineers' and Architects' Club of Louisville, Ky., 303 Norton Building, Fourth and Jefferson Streets, Louisville, Ky.

Engineers' Club of Baltimore, Baltimore, Md.

Engineers' Club of Minneapolis, 17 South Sixth Street, Minneapolis, Minn.

Engineers' Club of Philadelphia, 1317 Spruce Street, Philadelphia, Pa.

Engineers' Club of St. Louis, 3817 Olive Street, St. Louis, Mo.

Engineers' Club of Toronto, 96 King Street, West, Toronto, Ont., Canada.

Engineers' Society of Northeastern Pennsylvania, 302 Board of Trade Building, Scranton, Pa.

Engineers' Society of Pennsylvania, 219 Market Street, Harrisburg, Pa.

Engineers' Society of Western Pennsylvania, 2511 Oliver Building, Pittsburgh, Pa.

Institute of Marine Engineers, 58 Romford Road, Stratford, London, E., England.

Institution of Engineers of the River Plate, Buenos Aires, Argentine Republic.

Institution of Naval Architects, 5 Adelphi Terrace, London, W. C., England.

Junior Institution of Engineers, 39 Victoria Street, Westminster, S. W., London, England.

Koninklijk Instituut van Ingenieurs, The Hague, The Netherlands.

Louisiana Engineering Society, 321 Hibernia Bank Building, New Orleans, La.

Memphis Engineering Society, Memphis, Tenn.

Midland Institute of Mining, Civil and Mechanical Engineers, Sheffield, England.

Montana Society of Engineers, Butte, Mont.

North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne, England.

Oesterreichischer Ingenieur= und Architekten=Verein, Eschenbachgasse 9, Vienna, Austria.

Pacific Northwest Society of Engineers, 803 Central Building, Seattle, Wash.

Rochester Engineering Society, Rochester, N. Y.

Sachsischer Ingenieur- und Architekten-Verein, Dresden, Germany.

Sociedad Colombiana de Ingenieros, Bogota, Colombia.

Sociedad de Ingenieros del Peru, Lima, Peru.

Societe des Ingenieurs Civils de France, 19 Rue Blanche, Paris, France.

Society of Engineers, 17 Victoria Street, Westminster, S. W., London, England.

Svenska Teknologforeningen, Brunkebergstorg 18, Stockholm, Sweden.

Tekniske Forening, Vestre Boulevard 18–1, Copenhagen, Denmark.

Western Society of Engineers, 1737 Monadnock Block, Chicago, Ill.

ACCESSIONS TO THE LIBRARY

(From October 4th to November 5th, 1912)

DONATIONS*

A TREATISE ON HYDRAULICS.

By William Cawthorne Unwin. Second Edition. Cloth, 8¾ x 5½ in., illus., 11 + 339 pp. London, Adam and Charles Black; New York, The Macmillan Company, 1912. $4.25. (Donated by The Macmillan Company.)

The first edition of this work was issued in September, 1907. In the preface to that edition, the author states that in dealing with the practical problems of hydraulics the engineer has recourse to simple mechanical principles and simplified assumptions which furnish rough formulas. At present, it is stated, there are great numbers of these experimental formulas and data which are of varying trustworthiness and importance and on which the engineer has to rely in deciding questions which arise in many branches of his work. In any treatise of these experimental data, the author states that it seems to be difficult to give a sufficient account of them to enable the student to realize their limitations; in his book, therefore, full references are said to have been given to the primary sources in original memoirs, in order that the student may supplement the brief statements in the text. The author states that, in using this book, it is important that the problems concerning the flow of incompressible fluids and the closely related problems dealing with compressible fluids should be treated together. Numerical examples, selected from those set by the author for his students, have been added to most chapters of the book. In the present edition, some corrections are said to have been made, and a short summary of more recent researches is given in an appendix. The Chapter headings are: Units of Measurement; Properties of Fluids; Distribution of Pressure in a Liquid Varying with the Level; Principles of Hydraulics; Discharge from Orifices; Notches and Weirs; Statics and Dynamics of Compressible Fluids; Fluid Friction; Flow in Pipes; Distribution of Water by Pipes; Later Investigations of Flow in Pipes; Flow of Compressible Fluids in Pipes; Uniform Flow of Water in Canals and Conduits; Gauging of Streams; Impact and Reaction of Fluids; Appendix and Tables; Index.

MODERN ILLUMINATION THEORY AND PRACTICE.

By Henry C. Horstmann and Victor H. Tousley. Leather, 7 x 4¾ in., illus., 273 pp. Chicago, Frederick J. Drake & Company, 1912. $2.00.

The authors' aim has been to provide, in this book, a thorough and practical guide containing all the information necessary to the successful installation of good illumination for users, architects, contractors, and electricians. Only as much of the theory as is necessary to a thorough comprehension of the underlying principles of the subject is given, the work being intended, it is stated, for the practical workman rather than the student. The arrangement and treatment of the various sources of illumination are said to be systematic, and attention is called to the chapter dealing with the preparation of plans and specifications for wiring and illuminating and also to that entitled "Practical Considerations" which the authors state should be consulted freely by persons planning illuminations. The Chapter headings are: Light; Principles of Vision; Reflection, Refraction, and Diffusion; Photometry; Calculation of Flux from Photometric Curves; Illumination Calculations; Characteristics of Electric Illuminants; Shades and Reflectors; Location and Height of Lamps; Color of Light; Choice of Lamps; Choice of Fixtures; Indirect Lighting; Practical Considerations; Table of Intensities in Foot Candle for Various Classes of Service; Plans and Specifications; Illumination Tables; Incandescent Light Wiring and Other Tables; Glossary of Terms and Phrases; Tables of Square Roots and Standard Symbols; Index.

A TEXT-BOOK OF PHYSICS.

Edited by A. Wilmer Duff. (Blakiston's Science Series.) Third Edition, Revised. Cloth, 8½ x 5½ in., illus., 16 + 686 pp. Philadelphia, P. Blakiston's Son & Co., 1912.

This book represents, it is stated, the attempt of seven experienced teachers of college physics to prepare a text-book on the subject which will be satisfactory to them and to other teachers. In this, the third, edition, extensive changes are stated to have been made in the subject-matter of all the parts, while the sections relating to Heat and Electricity and Magnetism are entirely new. The order of subjects has also been changed somewhat, and, to facilitate reference, a list of tables of constants has been included. At the end of each part, a list of references to books relating to the subject is given as well as problems on the subjects and their answers. The Contents are: Mechanics and the Properties of Matter, by A. Wilmer Duff; Wave Motion, by E. Percival Lewis; Heat, by Charles E. Mendenhall; Electricity and Magnetism, by Albert P. Carman; Conduction of Electricity Through Gases and Radio-Activity, by R. K. McClung; Sound, by William Hallock; Light, by E. Percival Lewis; Index to Names; Index to Subjects.

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*Unless otherwise specified, books in this list have been donated by the publishers.

TEXT-BOOK ON THE STRENGTH OF MATERIALS.

By S. E. Slocum and E. L. Hancock. Revised Edition. Cloth, 9½ x 6¼ in., illus., 36 + 372 pp. Boston, New York, Chicago and London, Ginn and Company, 1911. $3.00.

The first edition of this work was published in 1906, and in order to utilize the numerous suggestions for its improvement received by the authors since that time from various sources, the subject-matter, it is stated, has been thoroughly revised, the object being to keep it abreast of the most recent practical developments of the subject and to simplify the method of its presentation. In Part I a set of tables has been added and placed at the beginning of the work to facilitate the numerical calculation. There are also, it is stated, new articles on the design of reinforced concrete beams, shrinkage, and forced fits, the design of eccentrically loaded columns, etc., including the derivation and application of the Frankel formula for the bending deflection of beams and also a simple general formula for the shearing deflection of beams never before published. Original problems to the number of about 150 have also been added to Part I, many of them being practical shop problems which have been selected, it is stated, for the purpose of emphasizing the practical importance of the subject and extending the range of its application as widely as possible. In Part II, it is stated, the recent advances in the manufacture of steel have been given special attention, including the properties of vanadium, manganese, and high-speed steels. The chapter on reinforced concrete is said to have been thoroughly revised and modernized, and this is also true of the chapter on timber, considerable new material on preservative processes having been added to the latter. The Contents are: Part I, Mechanics of Materials: Elastic Properties of Materials; Fundamental Relations Between Stress and Deformation; Analysis of Stress in Beams; Flexure of Beams; Columns and Struts; Torsion; Spheres and Cylinders Under Uniform Pressure; Flat Plates; Curved Pieces; Hooks, Links, and Springs; Arches and Arched Ribs; Foundations and Retaining Walls. Part II, Physical Properties of Materials: Iron and Steel; Lime, Cement, and Concrete; Reinforced Concrete; Brick and Building Stone; Timber; Rope, Wire, and Belting; Answers to Problems; Index.

GAS-ENGINE PRINCIPLES.

By Roger B. Whitman. Cloth, 7¾ x 5 in., illus., 15 + 248 pp. New York and London, D. Appleton and Company, 1912. $1.50.

In a secondary title, the author states that this book contains "explanations of the operations, parts, installation, handling, care, and maintenance of the small stationary and marine engine and chapters on the effect, location, remedy, and prevention of engine troubles." The preface further states that the author's purpose has been to explain the use of such engines in a practical and simple manner, instruction in engine design and comparison of merits of different types being purposely omitted. The Contents are: Gas-Engine Principles; Engine Types; Engine Parts; Valves and Valve Mechanism; Carburetion; Ignition and Electrical Principles; Electric Generators; Make-and-Break Systems; Jump Spark Ignition System; Lubrication and Cooling; Power, Care, and Maintenance; Causes of Trouble; Effects of Trouble; Testing for Trouble; Index.

REINFORCED CONCRETE CONSTRUCTION.

Vol. 1, Fundamental Principles, Including Numerous Tables and Diagrams to Facilitate the Calculation and Design of Reinforced Concrete Structures. By George A. Hool. (Engineering Education Series.) Cloth, 9½ x 6¼ in., illus., 10 + 254 pp. New York and London, McGraw-Hill Book Company, 1912. $2.50.

The preface states that this volume forms the first part of the regular course on Reinforced Concrete Construction offered by the Extension Division of the University of Wisconsin. The author presupposes a knowledge of the elements of structures on the part of the student, and while the book has been written primarily for a study of the subject by correspondence, he states that it may be used for other purposes, the text being intended to be supplemented with such other material as is suited to the special needs of the individual student. The text, as stated in the title, relates chiefly to the fundamental principles of the subject and is divided into two parts, namely, Properties of the Material, and the Theory and Design of Slabs, Beams, and Columns. At the end of each chapter problems relating to the subject discussed in that chapter are appended, and numerous tables and diagrams are also included. The Contents are: Part I, Properties of the Material: Concrete; Steel; Concrete and Steel in Combination. Part II, The Theory and Design of Slabs, Beams, and Columns: Rectangular Beams; Slabs, Cross-Beams, and Girders; Columns; Slab, Beam, and Column Tables; Slab, Beam, and Column Diagrams; Bending and Direct Stress Tables; Diagrams; Index.

THE DESIGN OF STEEL MILL BUILDINGS

And the Calculation of Stresses in Framed Structures. By Milo S. Ketchum, M. Am. Soc. C. E. Third Edition, Enlarged. Cloth, 9 x 6¼ in., illus., 16 + 478 + 78 pp. New York and London, McGraw-Hill Book Company, 1912. $4.00.

In this edition of this work many revisions and additions have been made, it is stated, several chapters having been rewritten and enlarged and many of the cuts redrawn. The more important additions are Appendix II, Two Problems in Graphic Statics, and Appendix III, Structural Drawings, Estimates and Designs, which, it is said, furnish data and tables not readily available elsewhere. The book is intended to provide a short course in the calculation of stresses in framed structures and to give a brief discussion of mill building construction, and while it is concerned chiefly with mill buildings, the subject-matter will also apply, it is stated, to all classes of steel frame construction. The book is divided into four parts and appendices: Part I, Loads, which relates to the various loads, dead loads, snow loads, wind loads, etc., to be provided for in designing a mill building. Part II, Stresses, in which part both the algebraic and graphic methods of calculating stresses are fully described and analyzed. This part relates mainly to the design of mill buildings, but it is said to contain also a number of problems only indirectly related to that subject. In Part III, Design of Mill Buildings, the methods of construction, and the material used are described, together with a brief treatment of mill building design and the making of estimates of weight and cost, the idea being to give methods, data, and details not ordinarily available and to discuss the matter presented in a manner which will be helpful to the engineer and the detailer. Part IV, Miscellaneous Structures, contains descriptions of hotels, locomotive shops, roundhouses, etc., with loads, stresses, etc., for each. Appendix I contains specifications for steel frame buildings, Appendix II, problems in graphic statics and the calculation of stresses, and the Index, and Appendix III, structural drawings, estimates, and designs, the latter being entirely new.

TRANSMISSION LINE CONSTRUCTION:

Methods and Costs. By R. A. Lundquist. Cloth, 9½ x 6½ in., illus., 8 + 295 pp. New York and London, McGraw-Hill Book Company, 1912. $3.00.

The author's aim, in this book, has been, it is stated, to supply detailed material of value to the man engaged in laying out and building a modern high-tension line, by setting forth the merits of the various types and the methods commonly used in their construction. No attempt has been made, it is stated, to cover the electrical and mechanical calculations involved, the treatment being from the standpoint of the construction man rather than that of the office engineer. Considerable attention has been given, it is stated, to cost data and to all conditions which may affect costs, and an effort has been made to make such data as definite, reliable and useful as possible. The Appendices contain specifications for various materials used in the construction of transmission lines. The Contents are: Preliminary Work; Location of Line—Surveys and Engineering; Types of Construction; Wooden Pole Construction; Steel Pole Construction; Steel Tower Construction; Reinforced Concrete Construction; Special Structures; Cross-Arms, Hardware, Pins, and Insulators; Guying; Stringing Wire; Cost Data of Typical Transmission Lines; Organization and Tools; Appendices; Index.

THE CITY THAT WAS.

By Stephen Smith. Cloth, 8 x 5¼ in., illus., 211 pp. New York, Frank Allaben, 1911. $1.25.

In a note by the publisher this work is stated to be the history of a great life-saving social revolution, in which the author lays bare the New York of 1864. It is said to be the story of the awakening of the citizens of New York to the need for better sanitary conditions after the Civil War, and what was done to obtain such conditions, by one of the chief actors of the event, Dr. Smith, an investigator of the conditions described. The Contents are: A Blind Metropolis and Her Dying Children; A Great Awakening; The Awakening in America; New York the Unclean; Victory; The Legal Work of Dorman Bridgeman Eaton; The Occult Power of Filth; A Closing Word.

Gifts have also been received from the following:

Alexander & Dowell. 1 pam.
Am. Ceramic Soc. 1 vol.
Am. Iron and Steel Assoc. 1 pam.
Am. Soc. of Heating and Ventilating Engrs. 1 bound vol.
Appleton, Thomas. 5 pam.
Architectural Record Co. 1 bound vol.
Arnold, Bion J. 1 pam.
Assoc. of Am. Portland Cement Mfrs. 1 pam.
Assoc. of Ry. Telegraph Supts. 1 pam.
Atchison, Topeka & Santa Fe Ry. Co. 1 pam.
Atlanta & West Point R. R. Co. 5 pam.
Attleborough, Mass.-Town Clerk. 15 vol.
Australia-Bureau of Census and Statistics. 1 bound vol.
Baker, I. O. 1 pam.
Baltimore, Md.-Harbor Board. 1 pam.
Bangor & Aroostook R. R. Co. 1 pam.
Binghamton, N. Y.-City Engr. 3 bound vol.
Bloomington, Ill.-City Clerk. 2 vol.
Boston, Mass.-Fire Commr. 12 bound vol., 10 vol.
Boston, Mass.-Statistics Dept. 3 vol.
Boston & Maine R. R. Co. 1 pam.
Bradford, Pa.-City Clerk. 2 vol.
Buffalo, N. Y.-Mayor. 13 pam.
Buffalo, Rochester & Pittsburgh Ry. Co. 3 pam.
Burlington, Iowa-City Clerk. 4 pam.
Bush Terminal Co. 6 pam.
Cambridge, Mass.-Water Board. 1 pam.
Camden, N. J.-Chf. Engr. 1 pam.
Canada-Dept. of Mines. 4 vol., 2 pam.
Canton, Ohio-City Auditor. 4 pam.
Carnegie Steel Co. 2 bound vol., 2 pam.
Central of Georgia Ry. Co. 1 pam.
Central R. R. Co. of New Jersey. 2 pam.
Central Vermont Ry. Co. 1 pam.
Chattanooga, Tenn.-Mayor. 7 pam.
Chelsea, Mass.-City Clerk. 5 bound vol.
Chesapeake & Ohio Ry. Co. 1 pam.
Chicago, Ill.-Harbor and Subway Comm. 1 pam.
Chicago & Eastern Illinois R. R. Co. 2 pam.
Chicago, Burlington & Quincy R. R. Co. 1 pam.
Chicago Great Western R. R. Co. 2 pam.
Chicago Junction Rys. & Union Stock Yards Co. 5 pam.
Chicago, Rock Island & Pacific Ry. Co. 1 pam.
Cincinnati. New Orleans & Texas Pacific Ry. Co. 4 pam.
Cleveland, Ohio-City Clerk. 4 bound vol.
Cleveland, Akron & Cincinnati Ry. Co. 1 pam.
Cleveland, Akron & Columbus Ry. Co. 4 pam.
Colorado-Agri. Exper. Station. 1 pam.
Colorado & Southern Ry. Co. 3 pam.
Colorado School of Mines. 1 pam.
Colorado, Univ. of. 1 pam.
Cripple Creek Central Ry. Co. 2 pam.
Detroit United Ry. Co. 10 pam.
Duluth, Minn.-City Clerk. 9 vol.
East Orange, N. J.-City Council. 2 vol.
Elmira, N. Y.-City Clerk. 1 vol.
Engrs. Soc. of Western Pennsylvania. 1 pam.
Erie, Pa.-City Clerk. 3 pam.
Erie & Pittsburgh R. R. Co. 4 pam.
Erie R. R. Co. 1 pam.
Evanston, Ill.-City Clerk. 11 pam.
Fall River, Mass.-City Clerk. 17 bound vol.
Fall River, Mass.-City Engr. 3 pam.
Fitchburg, Mass.-Water Commrs. 1 pam.
Florida-State Board of Health. 1 vol.
Fonda, Johnstown & Gloversville R. R. Co. 1 pam.
Force, H. J. 2 pam.
Freeman, John R. 1 bound vol.
Fudge, Edward. 11 pam.
Georgia-R. R. Comm. 1 vol.
Germany-Preussische Landesanstalt für Gewässerkunde. 7 pam.
Goltra, W. F. 1 pam.
Grand Rapids, Mich.-City Engr. 8 pam.
Graves, Walter H. 1 pam.
Great Northern Ry. Co. 1 pam.
Greenalch, Wallace. 10 bound vol.
Griffith, W. F. R. 1 map.
Hamilton, Ont.-City Engr. 3 bound vol., 1 pam.
Harrisburg, Pa.-City Clerk. 1 vol.
Hawaii-Commr. of Agri. and Forestry. 2 pam.
Hering, Rudolph. 2 pam.
Hocking Valley Ry. Co. 1 pam.
Houston, Tex.-City Clerk. 1 vol.
Hudson & Manhattan R. R. Co. 2 pam.
Huntingdon & Broad Top Mountain R. R. & Coal Co. 4 pam.
Illinois Central R. R. Co. 1 pam.
Illinois, Univ. of. 1 vol.
Illuminating Eng. Soc. 1 pam.
Institution of Civ. Engrs. 2 bound vol.
Institution of Elec. Engrs. 1 vol.
Institution of Naval Archts. 1 bound vol.
Iowa State Coll. of Agri. and Mechanic Arts-Eng. Exper. Station. 1 pam.
Jersey City, N. J.-Board of Street and Water Commrs. 1 pam.
Joliet, Ill.-City Clerk. 1 pam.
Kansas City Southern Ry. Co. 5 pam.
Keene, N. H.-City Clerk. 9 bound vol., 4 vol.
Lackawanna Steel Co. 1 pam.
Lanagan, Frank R. 2 pam.
Lebanon, N. H.-Water Commrs. 9 pam.
Leeds, England-Sewerage Engr. 1 pam.
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RESIGNATIONS

JUNIORS	Date of Resignation.
BATES, LINDON, JR.	Oct. 29, 1912

DEATHS

BUCHHOLZ, CARL WALDEMAR. Elected Member, September 1st, 1886; died October 20th, 1912.

HOLMAN, STEPHEN. Elected Fellow, June 29th, 1872; died October 13th, 1912.

MOHUN, EDWARD. Elected Member, April 6th, 1892; died October 23d, 1912.

WHITE, HENRY FISHER. Elected Member, January 2d, 1890; date of death unknown.

WISE, JAMES HUGH. Elected Associate Member, February 6th, 1907; died September 16th, 1912.

Total Membership of the Society, November 7th, 1912,
6 748

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(October 2d to November 5th, 1912)

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(2) *Proceedings,* Engrs. Club of Phila., Philadelphia, Pa.
(3) *Journal,* Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal,* Western Soc. of Engrs., Chicago, Ill., 50c.
(5) *Transactions,* Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly,* Columbia Univ., New York City, 50c.
(7) *Gesundheits Ingenieur,* München, Germany.
(8) *Stevens Institute Indicator,* Hoboken, N. J., 50c.
(9) *Engineering Magazine,* New York City, 25c.
(10) *Cassier's Magazine,* New York City, 25c.
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(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News,* New York City, 15c.
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(17) *Electric Railway Journal,* New York City, 10c.
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(19) *Scientific American Supplement,* New York City, 10c.
(20) *Iron Age,* New York City, 20c.
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(25) *American Engineer,* New York City, 20c.
(26) *Electrical Review,* London, England, 4d.
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(29) *Journal,* Royal Society of Arts, London, England, 6d.
(30) *Annales des Travaux Publics de Belgique,* Brussels, Belgium, 4 fr.
(31) *Annales* de l'Assoc. des Ing. Sortis des Ecoles Spéciales de Gand, Brussels, Belgium, 4 fr.
(32) *Mémoires et Compte Rendu des Travaux,* Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil,* Paris, France, 1 fr.
(34) *Portefeuille Economiques des Machines,* Paris, France.
(35) *Nouvelles Annales de la Construction,* Paris, France.
(36) *Cornell Civil Engineer.* Ithaca, N. Y.
(37) *Revue de Mécanique,* Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways,* Paris, France.
(39) *Technisches Gemeindeblatt,* Berlin, Germany, 0, 70m.
(40) *Zentralblatt der Bauverwaltung,* Berlin, Germany, 60 pfg.
(41) *Elektrotechnische Zeitschrift,* Berlin, Germany.
(42) *Proceedings,* Am. Inst. Elec. Engrs., New York City, $1.
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(49) *Zeitschrift für Bauwesen,* Berlin, Germany.
(50) *Stahl und Eisen,* Düsseldorf, Germany.
(51) *Deutsche Bauzeitung,* Berlin, Germany.
(52) *Rigasche Industrie-Zeitung,* Riga, Russia, 25 kop.
(53) *Zeitschrift,* Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria, 70h.

(54) *Transactions*, Am. Soc. C. E., New York City, $4.
(55) *Transactions*, Am. Soc. M. E., New York City, $10.
(56) *Transactions*, Am. Inst. Min. Engrs., New York City, $6.
(57) *Colliery Guardian*, London, England, 5d.
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(62) *Industrial World*, 59 Ninth St., Pittsburgh, Pa., 10c.
(63) *Minutes of Proceedings*, Inst. C. E., London. England.
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(70) *Engineering Review*, New York City, 10c.
(71) *Journal*, Iron and Steel Inst., London, England.
(71*a*) *Carnegie Scholarship Memoirs*, Iron and Steel Inst., London, England.
(72) *American Machinist*, New York City, 15c.
(73) *Electrician*, London, England, 18c.
(74) *Transactions*, Inst. of Min. and Metal., London, England.
(75) *Proceedings*, Inst. of Mech. Engrs., London, England.
(76) *Brick*, Chicago, Ill., 10c.
(77) *Journal*, Inst. Elec. Engrs., London, England, 5s.
(78) *Beton und Eisen*, Vienna, Austria, 1, 50m.
(79) *Forscherarbeiten*, Vienna, Austria.
(80) *Tonindustrie Zeitung*, Berlin, Germany.
(81) *Zeitschrift für Architektur und Ingenieurwesen*, Wiesbaden, Germany.
(83) *Progressive Age*, New York City, 15c.
(84) *Le Ciment*, Paris, France.
(85) *Proceedings*, Am. Ry. Eng. Assoc., Chicago, Ill.
(86) *Engineering-Contracting*. Chicago, Ill., 10c.
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(88) *Bulletin* of the International Ry. Congress Assoc., Brussels, Belgium.
(89) *Proceedings*, Am. Soc. for Testing Materials, Philadelphia, Pa., $5.
(90) *Transactions*, Inst. of Naval Archts., London, England.
(91) *Transactions*, Soc. Naval Archts. and Marine Engrs., New York City.
(92) *Bulletin*, Soc. d'Encouragement pour l'Industrie Nationale, Paris, France.
(93) *Revue de Métallurgie*, Paris, France, 4 fr. 50.
(94) *The Boiler Maker*, New York City, 10c.
(95) *International Marine Engineering*, New York City, 20c.
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(98) *Journal*, Engrs. Soc. Pa., Harrisburg, Pa., 30c.
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(100) *Professional Memoirs*, Corps of Engrs., U. S. A., Washington, D. C., 50c.
(101) *Metal Worker*, New York City, 10c.
(102) *Organ für die Fortschritte des Eisenbahnwesens*, Wiesbaden, Germany.
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(104) *The Surveyor and Municipal and County Engineer*, London, England, 6d.
(105) *Metallurgical and Chemical Engineering*, New York City, 25c.
(106) *Transactions*, Inst. of Mining Engrs., London, England, 6s.
(107) *Schweizerische Bauzeitung*, Zürich, Switzerland.
(108) *Southern Machinery*, Atlanta, Ga., 10c.

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A Sixty Thousand Horse-Power Blast Furnace Gas Engine Plant.* C. A. Tupper. (19) Oct. 26.

Heat-Treating Furnaces. Metallurgical Laboratory of Carnegie Institute of Technology, Pittsburgh.* James A. K. Knapp. (62) Oct. 28; (20) Oct. 17.

Use of Mayari Iron in Foundry Mixtures.* Quincy Bent. (Paper read before the Am. Iron and Steel Inst.) (20) Oct. 31.

Progress in the Preparation of Iron Ores. J. W. H. Hamilton. (Paper read before the Am. Iron and Steel Inst.) (20) Oct. 31.

The Thermal Conductivity of Carburizing Materials. J. H. Nead and J. N. Bourg. (13) Oct. 31.

Economic Efficiency in Lead Concentration.* R. S. Handy. (45) Nov.

Causes of the Practical Non-Success of Electric Furnaces in Treating Zinc Ores. Francis Louvrier. (105) Nov.

Jigging Unsized Ores.* Edward T. Wright. (105) Nov.

Iron Ore Concentration in Minnesota.* (105) Nov.

Cyanidation in the Cobalt District.* Herbert A. Megraw. (16) Nov. 2.

Epuration des Gaz de Hauts-Fourneaux.* A. Gouvy. (93) Oct.

Dosage du Carbone Total des Aciers et des Ferroalliages par Combustion sous Pression d'Oxygène.* P. Mahler et E. Goutal. (93) Oct.

Quelques Mots sur l'Analyse du Minerai de Platine. E. V. Koukline. (93) Oct.

Ueber verschiedene Arten von Schlackeneinschlüssen im Stahl, ihre mutmassliche Herkunft und ihre Verminderung.* Fr. Pacher. (50) Oct. 3.

Ueber die Verwendung von Kohlenstoffsteinen im Hochofenbetrieb.* C. Geiger. (50) Oct. 10.

Ueber Silikasteine für Martinöfen.* Otto Lange. (50) Oct. 17.

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Smokeless Powders and Explosives for Military Use. Odus C. Horney. (2) Oct.

A Triple Mirror for Secret Signaling.* C. H. Claudy. (46) Oct. 26.

Ordnance Manufacture at South Bethlehem. E. G. Grace. (Paper read before the Am. Iron and Steel Inst.) (20) Oct. 31.

Mortar Fire, A System for Attacking the Decks of Battleships.* Charles A. Junken. (46) Nov. 2.

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Ferro-Concrete Lining to Mine Shafts. (29) Sept. 27.

Gold Dredging on the Seward Peninsula.* Charles Janin. (103) Sept. 28.

Asbestos.* J. F. Springer. (10) Oct.

The Control of Fire in Mines. George S. Rice. (From Report, U. S. Bureau of Mines.) (10) Serial beginning Oct.

Moistening Mine Ventilating Currents. A. A. Steel. (45) Oct.

Revival of Mining at Red Cliff.* A. J. Hoskin. (45) Oct.

Buckner No. 2 Mine.* Warren Roberts and Oscar Cartlidge. (45) Oct.

Fireproof Shaft, Vermillion Mine.* A. F. Allard. (45) Oct.

Recent Rock-House Practice in the Copper Country.* Tenney C. De Soller. (Paper read before the Lake Superior Min. Inst.) (105) Oct.

Rock-House Practice at Copper Range Properties.* H. T. Mercer. (Paper read before the Lake Superior Min. Inst.) (105) Oct.

Geology, Mining and Preparation of Anthracite.* H. H. Stock. (4) Oct.

Tennessee Phosphate Practice. James Allen Barr. (45) Oct.

Brakpan Mines, Limited. H. S. Gilser. (45) Oct.

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Method of Raising a Shaft 621 Feet Through Rock.* Edward N. Cory. (Paper read before the Lake Superior Min. Inst.) (86) Oct. 2.

The Relative Inflammability of Coal Dusts.* (Report of Explosions in Mines Committee of Great Britain.) (57) Serial beginning Oct. 11.

Using Channelers for Cutting Condenser Well Trenches.* (From *Mine and Quarry.*) (14) Oct. 12.

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Iron Mining on the Mesabi Range.* A. L. Gerry. (16) Oct. 12.
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Determining Coal Values. E. G. Bailey. (45) Nov.
Results of Deep Mining in California.* Al. H. Martin. (45) Nov.

Miscellaneous.

Methods of Procedure Under the Wisconsin Utility Law, Benefits and Restrictions of the Law. C. B. Salmon. (Paper read before the Central States Water-Works Assoc.) (86) Oct. 16; (14) Oct. 26.
Methods of Determining Life of Public Utilities. Halford Erickson. (Abstract of paper read before the Central States Water-Works Assoc.) (86) Serial beginning Oct. 23.
The Use of Depreciation Data in Rate Making and Appraisal Problems. Halbert P. Gillette. (86) Oct. 30; (27) Nov. 2.
Practical Determination of the Magnifying Power of Telescopes.* William F. Endress. (10) Nov.
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Standard Abrasion Test for Road Material. (Am. Soc. for Testing Materials.) (89) Vol. 12.
Standard Toughness Test for Macadam Rock. (Am. Soc. for Testing Materials.) (89) Vol. 12.
Provisional Method for the Determination of Soluble Bitumen. (Am. Soc. for Testing Materials.) (89) Vol. 12.
Provisional Method for the Determination of the Penetration of Bitumen. (Am. Soc. for Testing Materials.) (89) Vol. 12.
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The Construction of Concrete Pavements. A. M. Compton. (67) Oct.
English Suggestions for Standard Specifications for Bituminous Bound Road Surfacing. John S. Brodie, M. Inst. C. E. (Paper read before the British Institution of Mun. and County Engrs.) (86) Oct. 2.
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Methods of Constructing Concrete Alley Pavement at Billings, Mont.* John N. Edy. (86) Oct. 9.
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Field Surveys for Road Construction. E. L. Griggs. (Paper read before the American Road Congress.) (86) Oct. 16; (96) Oct. 31.
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Cost of Leveling Ground with an Electric Drag Scraper (Street Leveling).* James C. Bennett. (13) Oct. 17.
Comparative Costs of Various Methods of Paying for Repairing in New York City. Nelson P. Lewis. (Report to the Board of Estimate and Apportionment.) (86) Oct. 23.
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Construction of Surfaces with Bituminous Materials. Arthur H. Blanchard, M. Am. Soc. C. E. (Paper read before the Am. Road Congress.) (96) Oct. 24; (14) Nov. 2.

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Concrete Guard Rail for Highways.* (14) Oct. 26; (13) Oct. 17.
The Paris Fire Department; Its Latest Equipment.* (19) Oct. 26.

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Manufacturers' Standard Specifications for Bessemer Steel Rails. (Assoc. of Am. Steel Manufacturers.) (89) Vol. 12.
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Standard Specifications for Steel Axles.* (Car and Engine.) (Am. Soc. for Testing Materials.) (89) Vol. 12.
Standard Specifications for Forged and Rolled, Forged, or Rolled Solid Carbon-Steel Wheels for Engine-Truck, Tender and Passenger Service. (Am. Soc. for Testing Materials.) (89) Vol. 12.
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Standard Specifications for Steel Tires.* (Am. Soc. for Testing Materials.) (89) Vol. 12.
Standard Specifications for Locomotive Materials.* (Am. Soc. for Testing Materials.) (89) Vol. 12.
The Accelerometer and Its Application to Railway Traction Problems.* Harry Egerton Wimperis. (63) Vol. 188.
The Concorde Tunnel of the Paris Metropolitan Railway.* Paul Seurot. (63) Vol. 188.
The Corrugation of Rails.* Alfred Schwartz and R. G. Cunliffe. (77) Sept.
The Railways of South America. R. Renewal. (10) Serial beginning Sept.
The Electrical Equipment of Railroad Shops.* Geo. W. Cravens. (61) Sept. 17.
The Belgian Method of Testing Locomotives While Running.* Strahl. (88) Oct.
Memorandum Concerning the Electrification of the Berlin Metropolitan, Circle and Suburban Railways.* Minister of Public Works of Prussia. (From *Elektrische Kraftbetriebe und Bahnen.*) (88) Oct.
Comparative Service Tests of Locomotive Road Trials on the B., R. & P. to Determine the Efficiency of the Superheater and Brick Arch. (25) Oct.
Compound Locomotive with Equal-Sized Cylinders.* C. R. K. (21) Oct.
The American Locomotive Company's Engine, No. 50 000.* (21) Oct.
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Locomotive Boiler Troubles. J. W. Harkom. (Abstract of paper read before the Canadian Ry. Club.) (94) Oct.
The Future of Locomotive Construction.* Leopold Kliment. (From *Die Lokomotive.*) (88) Oct.
Tunnel Inspection Car of the Saarbrücken Railway Directorate. Spiro. (From *Elektrische Kraftbetriebe und Bahnen.*) (88) Oct.
The Relation of Locomotive Boiler Design to Efficiency, Maintenance and Safety.* A. W. Whiteford. (65) Oct.
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Comparison of Chemical Constituents of Steel Rails from 1870 to Date. Paul M. La Bach. (15) Oct. 11.
Fuel Economy on the Buffalo, Rochester & Pittsburgh. (15) Oct. 11.
Culvert Waterways in Eastern Kansas.* W. C. Hoad. (Abstract of paper read before the Kansas Eng. Soc.) (14) Oct. 12.
Narrow-Gauge Locomotives for a Brazilian Road. (18) Oct. 12.
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Types of Defective Rails and Some Methods Used in Detaching Them.* Robert Job. (Paper read before the Inter. Soc. for Testing Materials.) (13) Oct. 17; (15) Nov. 1.
Concrete Coaling Stations.* C. P. Ross. (15) Oct. 18.
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Increased Tonnage per Locomotive Mile.* W. M. Baxter. (Paper read before Illinois Central R. R. Officials.) (18) Oct. 19.
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Some Notes from Experience with Reinforced Concrete Pipe Culverts for Railways. (Abstract of Report made to Committee of the Assoc. of Ry. Superintendents of Bridges and Bldgs.) (86) Oct. 23.
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Design of Turntables for Heavy Locomotives. C. E. Smith. (Abstract of Report to Am. Ry. Bridge and Building Assoc.) (14) Oct. 26.
Engineering Features of a Large Southern Lumbering Development, Including a Logging Railroad Through a Dense Swamp, Heavy Skidding Cableways, and an Industrial Town Improved with Sanitary Works. (14) Oct. 26.
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Etude sur les Locomotives de Montagne et Particulièrement la Locomotive Compound Articulée, Système Mallet.* A. Mallet. (32) Aug.
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Central Station Power for Electric Railways in Chicago.* Henry H. Norris. (17) Oct. 5; (27) Oct. 5.
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Report of Joint Committee on Block Signals for Electric Railways. (Abstract of paper read before the Am. Elec. Ry. Eng. and Transportation and Traffic Assoc.) (17) Oct. 9.
Winter Troubles on Electric Railways. Charles J. Jones. (Abstract of paper read before the Ill. Elec. Rys. Assoc.) (13) Oct. 10.
One-Man Prepayment Car Operation.* S. R. Inch. (Abstract of paper read before the Am. Elec. Ry. Transportation and Traffic Assoc.) (17) Oct. 11.
Report of the Committee on Equipment (Am. Elec. Ry. Eng. Assoc.). (17) Oct. 12.
Transportation in San Francisco. Bion J. Arnold. (14) Oct. 12; (17) Oct. 5.
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The Ventilation of Sewers. T. De Courcy Meade, M. Inst. C. E. (Paper read before the Royal Inst. of Public Health in Berlin.) (104) Sept. 27; (96) Oct. 24.
The Municipal Works of Grays. Arthur C. James, Assoc. M. Inst. C. E. (Paper read before the Inst. of Mun. and County Engrs.) (104) Sept. 27.
Cost of Making Cement Drain Tile. (67) Oct.
The Problem of Sewage Sludge in Natural Water-Courses, Measures of Prevention and Relief. Langdon Pearse. (Paper read before the Am. Public Health Assoc.) (86) Oct. 2.
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Sewage Disposal by Oxidation Methods. John Duncan Watson, M. Inst. C. E. (Paper read before the International Congress on Hygiene and Demography.) (104) Oct. 4; (13) Oct. 10.
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The Skilled Supervision of Sewage Purification Works. F. Herbert Snow. (Abstract of paper read before the Am. Public Health Assoc.) (13) Oct. 10.

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The Discharge of Effluents into Tidal Streams. D. Roberts. (Paper read before the Royal Sanitary Inst.) (104) Oct. 11.

Sewage Disposal at Barnsley. J. Henry Taylor, M. Inst. C. E. (Paper read before the Assoc. of Managers of Sewage Disposal Works.) (104) Oct. 11.

Sludge Accumulations at Sewer Outfalls. Langdon Pearse. (Abstract of paper read before the Am. Public Health Assoc.) (14) Oct. 12.

Heating and Ventilating Northwestern University Buildings.* J. M. Stannard. (Abstract of paper read before the Am. Soc. of Heating and Ventilating Engrs.) (64) Oct. 15.

Steam *vs.* Hot Water Heating at Northwestern University. Ira N. Evans. (64) Oct. 15.

The Hygienic Aspects of Gas for Heating and Lighting in Home, School and Workshop. Vivian B. Lewes. (Paper read before the British Commercial Gas Assoc.) (66) Oct. 15

Operating Results of the Imhoff Sewage Tank at Winters, Cal. Fred H. Tibbetts. (Paper read before the League of California Municipalities.) (86) Oct. 16; (96) Oct. 31.

Sewage Treatment *versus* Sewage Purification. George C. Whipple. (Paper read before the Am. Public Health Assoc.) (96) Oct. 17; (86) Oct. 23.

Electrolytic Disposition of Sewage. F. C. Caldwell. (From *Bulletin*, Ohio State University.) (96) Oct. 17.

The Influence of Town Planning Upon the Public Health. W. Louis Carr. (Paper read before the Inst. of Mun. Engrs.) (104) Oct. 18.

The Local Government Report on the Intercepting Trap. H. C. H. Shenton. (Paper read before the Inst. of Mun. Engrs.) (104) Oct. 18.

Rules and Legislation Regarding Compressed Air Work. Henry Japp. (Abstract of paper read before the Inter. Cong. of Hygiene and Demography.) (14) Oct. 19.

Plans of the Metropolitan Sewerage Commission. (14) Oct. 19.

Sewage Disposal by Oxidation. Robert Spurr Weston. (Paper read before the Inter. Cong. on Hygiene and Demography.) (14) Oct. 19.

Vapor Disposal System in a Dyehouse.* (14) Oct. 19.

The Solution of Hydraulic Problems Relating to Tile Drainage.* Louis Schmeer. (86) Oct. 23.

Methods of Sludge Disposal.* Karl Imhoff. (Paper read before the Inter. Cong. on Hygiene and Demography.) (13) Oct. 24.

Hot-Water Heating of Small Greenhouse.* (101) Oct. 25.

Elementary Theory and Principles of Street Cleaning. S. Whinery. (Abstract of paper read before the Am. Public Health Assoc.) (14) Oct. 26.

Sewage Disposal at an Ohio Institution, Protecting the Scioto River from Pollution by the Wastes from an Industrial Home.* R. Winthrop Pratt. (14) Oct. 26.

Gas *versus* Coal for Water Heating Appliances. D. W. Allman. (Paper read before the Michigan Gas Assoc.) (24) Oct. 28.

Heat Transmission Through Corrugated Iron.* A. H. Blackburn. (64) Oct. 29; (14) Oct. 12; (96) Oct. 31.

The Application of Engineering Practice and Principles for Controlling Municipal Activities, as Illustrated by the Work of the Street Cleaning Bureau, Borough of Richmond, New York City. George Cromwell. (Report to the Board of Estimate and Apportionment.) (86) Oct. 30.

Design and Construction of the O. K. Creek Sewer, Kansas City, Missouri; Diversion into a Large Concrete Sewer of a Stream Meandering Through the Site of the New Union Passenger Terminal.* (14) Nov. 2.

Conference on Pollution of Lakes and Waterways. (14) Nov. 2; (13) Oct. 31.

British Practice in Sewage Disposal. Arthur J. Martin. (Paper read before the Royal Inst. of Public Health.) (14) Nov. 2.

Les Travaux d'Assainissement de Wenduyne.* J. Soete. (30) Oct.

Sind die Berechnungsmethoden der Zentralheizungstechnik verbesserungsbedürftig?* Otto Ginsberg. (7) Serial beginning Sept. 14.

Vereinfachte Transmissionsberechnungen. R. Meisterhaus. (7) Sept. 21.

Untersuchungen über Wetterführung mittels Lutten.* Willy Arlt. (48) Serial beginning Sept. 28.

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Standard Specifications for Hard-Drawn Copper Wire.* (Am. Soc. for Testing Materials.) (89) Vol. 12.

Standard Specifications for Soft or Annealed Copper Wire. (Am. Soc. for Testing Materials.) (89) Vol. 12.

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Standard Methods of Testing. (Am. Soc. for Testing Materials.) (89) Vol. 12.

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Standard Test for Fireproof Floor Construction. (Am. Soc. for Testing Materials.) (89) Vol. 12.

Standard Test for Fireproof Partition Construction. (Am. Soc. for Testing Materials.) (89) Vol. 12.

Standard Specifications for Steel Reinforcing Bars. (Am. Soc. for Testing Materials.) (89) Vol. 12.

Standard Specifications for Structural Steel for Buildings.* (Am. Soc. for Testing Materials.) (89) Vol. 12.

Manufacturers' Standard Specifications for Structural Steel.* (Assoc. of Am. Steel Manufacturers.) (89) Vol. 12.

Standard Specifications for Steel Splice Bars. (Am. Soc. for Testing Materials.) (89) Vol. 12.

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Standard Specifications for Steel: Report of Committee A-1. (Am. Soc. for Testing Materials.) (89) Vol. 12.

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INSTITUTED 1852

PAPERS AND DISCUSSIONS

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AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

IRRIGATION AND RIVER CONTROL IN THE COLORADO RIVER DELTA.

By H. T. Cory, M. Am. Soc. C. E.

To be Presented January 1st, 1913.

From almost every point of view, the Lower Colorado River, and particularly the Colorado Delta, is extremely interesting. Ever since its examination and description by members of Lieut. Williamson's exploration party in 1850, the various features, geological, geographical, anthropological, engineering, and otherwise, have been written about. In 1905 the diversion of the Colorado River into the Salton Sea and the events which followed it were so spectacular as to result in world-wide notoriety.

While engaged in re-diverting the river, the writer became impressed with the fact that the experience and information obtained should be made available to the Engineering Profession, and since then he has constantly been gathering data to that end. In February, 1907, a general paper on the subject* was contributed to this Society by C. E. Grunsky, M. Am. Soc. C. E., then Consulting Engineer to the Secretary of the Interior in United States Reclamation Service matters; so that, before giving detailed information, it seemed best to wait until time should have revealed the strong and weak points

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

* "The Lower Colorado River and the Salton Basin," *Transactions*, Am. Soc. C. E., Vol. LIX, p. 1.

of construction and methods. Since then, experience with the control of the Lower Colorado River, and as local executive head of the immense irrigation project of the Imperial Valley, has brought the conclusion that the various possible vicissitudes of irrigation enterprises in the United States have been so well exemplified in the region as to justify setting forth such experience in considerable detail.

Ordinarily, more information is secured from failure than from success; consequently, no apology should be due for pointing out failures as well as successes in a paper, the functions of which are primarily to furnish useful engineering information.

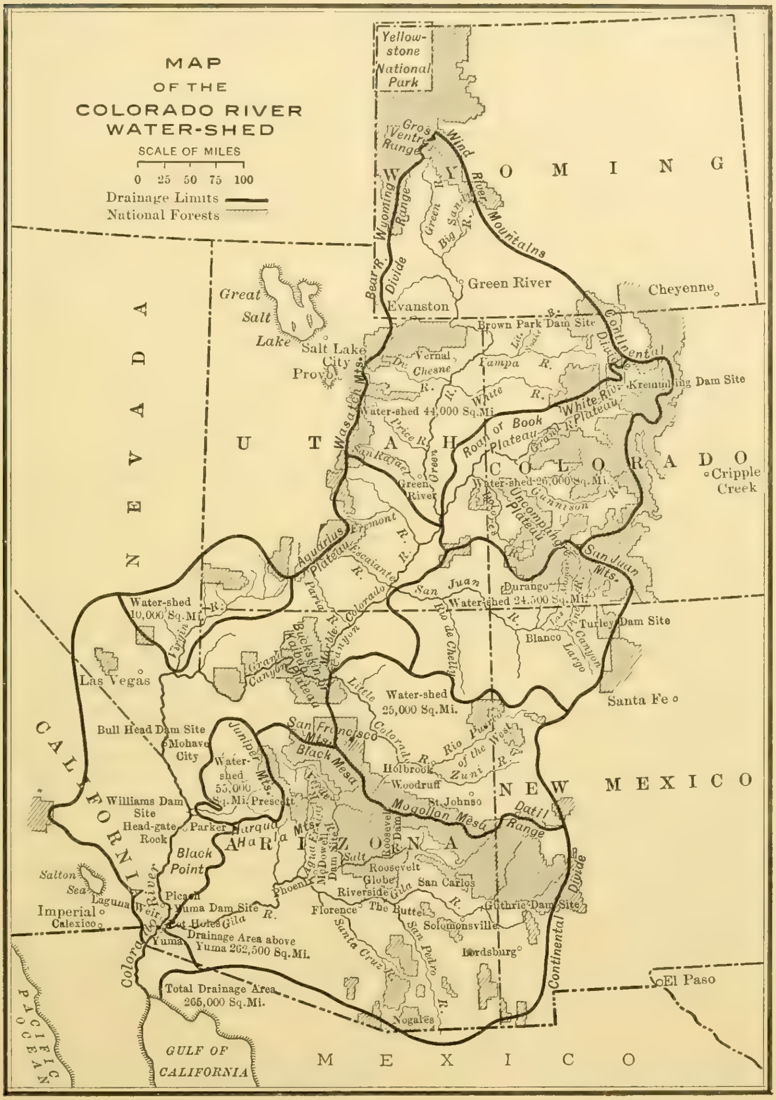
The Colorado River.

The United States Geological Survey has observed the discharge of the Colorado and its several tributaries since 1895, and the results are to be found in its Annual Reports and later in the Water Supply and Irrigation Papers, especially Nos. 249 and 269, on the Colorado River Basin. At various times 169 gauging stations have been maintained, and there are 76 at present.

General Discharge Characteristics.—From the data obtained at these stations, the discharge characteristics of the tributaries and main Colorado River are pretty well determined. The discharge records of the Green River, at Green River, Utah, the lowest gauging station above its mouth, and where the drainage area above it is 38 200 sq. miles, indicate a maximum flow of about 75 000 sec-ft., a minimum flow of about 700 sec-ft., and an average annual run-off of about 5 000 000 acre-ft. The greatest discharge is in June, averaging about 1 600 000 acre-ft.; the annual rise starts about April 1st, reaches its peak in the middle of June, and has passed by August 1st.

The data obtained on the Grand River indicate a proportionately great run-off and very much the same distribution throughout the year. The records, taken at Turley, N. Mex., on the San Juan River until December, 1908, and since then at Blanco, indicate an ordinary flood maximum of about 15 000 sec-ft., a minimum of 75 sec-ft., and an average annual discharge of 1 000 000 acre-ft., but with a much longer period of summer flood than in the Green and Grand.

The maximum flood discharge of the Little Colorado when it enters the Colorado River is not known, but is probably about 50 000 sec-ft. The floods are short and violent, and carry large quantities of silt in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Green River
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Evanston
Great Salt Lake
Salt Lake City
Provo
Brown Park Dam Site
Continental Divide
Vernal
Du Chesne R.
Yampa R.
Kremmling Dam Site
Water-shed 44,000 Sq.Mi.
White R.
White River Plateau
Wasatch Mts.
N E V A D A
U T A H
Price R.
Roan or Book Plateau
Grand R.
C O L O R A D O
Cripple Creek
San Rafael
Green River
Water-shed 26,000 Sq.Mi.
Gunnison R.
Uncompahgre Plateau
Fremont R.
Aquarius Plateau
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Water-shed 24,500 Sq.Mi.
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Water-shed 10,000 Sq.Mi.
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Grand Canyon
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Little Colorado R.
Water-shed 25,000 Sq.Mi.
Santa Fe
C A L I F O R N I A
Bull Head Dam Site
Mohave City
Juniper Mts.
Water-shed 55,000 Sq.Mi.
San Francisco Mts.
Black Mesa
Rio Puerco of the West R.
Holbrook
Zuni R.
Woodruff
St. Johns
N E W M E X I C O
Williams Dam Site
Head-gate Rock
Parker
Prescott
Mogollon Mesa
Datil Range
Harqua Hala Mts.
Verde R.
A R I Z O N A
Roosevelt Dam
Black Point
McDowell Dam
Salt R.
Roosevelt
Globe
San Carlos
Salton Sea
Picacho
Phoenix
Riverside
Gila R.
Guthrie Dam Site
Laguna Weir
Yuma Dam Site
Florence
The Buttes
Imperial
Calexico
Colorado River
Dome
Gila R.
Solomonsville
Yuma
Drainage Area above Yuma 262,500 Sq.Mi.
Santa Cruz R.
San Pedro R.
Lordsburg
Continental Divide
El Paso
Total Drainage Area 265,000 Sq.Mi.
Nogales
PACIFIC OCEAN
GULF OF CALIFORNIA
M E X I C O

FIG. 1.

suspension, in which regard the stream is similar to the Gila and Salt Rivers.

The Gila at Yuma is often dry, and has a maximum flashy flood discharge of probably 185 000 sec-ft. with a total average annual run-off of 2 750 000 acre-ft. Flashy floods have been known to occur in every month of the year except May, June, and July, at which times the Colorado has its maximum flow.

Power.—Excellent reservoir sites have been found on the head-waters and along the main channels of the various tributaries, by utilizing which a considerable portion of the flow could be stored for power and irrigation. Such storage would equalize the discharge, that for power having the greater relative influence. There are at present no water-power plants of any importance whatever in the whole drainage area of the Green River. A total of approximately 40 000 h.p. has been developed in the Grand, 7 000 in the San Juan, and 20 000 in the Gila Basin, in connection with irrigation construction. No data seem to be available as to the amount of energy which it is commercially practicable to develop under existing conditions on these various streams—it is obvious that there must be a vast difference between the figures for theoretically possible and for commercially feasible developments.

Irrigation.—The water of the streams making up the Colorado is already utilized for irrigation to a considerable extent. The oldest and largest development in the basin is perhaps that on the upper Green River, in Wyoming. Recently, large irrigation systems have been constructed in the Duchesne River Basin, and there is considerable irrigation around Vernal, and also Green River, Utah. Along the White and Yampa Rivers, in Colorado, meadow irrigation is extensively practiced, and projects are on foot for the irrigation of from 200 000 to 300 000 acres in this section.

Similarly, in the Grand Basin, there are extensive meadow lands in the upper part, and a half dozen small projects in contemplation for the Middle Basin which together would irrigate about 35 000 acres. In the Lower Basin is the Grand Valley Project, covering an irrigable area of 70 000 acres, and the Uncompahgre Valley Project, which, when completed, will irrigate about 150 000 acres, both by the United States Reclamation Service. Under other schemes, from 40 000 to 50 000 acres more will be irrigated.

Quite a little land along the San Juan, Animas, Pine, Florida, and La Plata Rivers, and the small tributaries of the San Juan, in Colorado, is now under cultivation, and also several thousand acres of valley land in New Mexico, but, as yet, irrigation has largely been confined to the bottom lands. The greatest probability of future irrigation development in this basin is in San Juan County, New Mexico, where it is said that probably 1 000 000 acres of fertile lands are excellently adapted for irrigation, for which the water supply is ample, the average annual run-off at Turley dam site being probably more than 1 000 000 acre-ft., and the reservoir at that point having a capacity of 1 500 000 acre-ft.

In the Little Colorado River Basin there are scattered a few relatively unimportant patches of irrigated land, while the U. S. Reclamation Service has investigated and found feasible the irrigation of approximately 70 000 acres in the vicinity of Holbrook, by constructing storage reservoirs at St. John's and Woodruff, Ariz.

There are also irrigation possibilities in the Virgin River and Bill Williams Fork Basins, but their total area is relatively unimportant, as far as concerns their effect on floods, or the irrigation of lower lands.

There are excellent opportunities for irrigation in the Gila River Basin, chief of which are the projects examined by the U. S. Reclamation Service in the vicinity of Alma and Lordsburgh, N. Mex. At the latter point there are 250 000 acres of almost unbroken and very fertile land which could be irrigated by the stored water of the Gila River, although at considerable expense. Other good storage sites exist at San Carlos on the Gila, and at Roosevelt on the Salt, the latter having already been utilized by the U. S. Reclamation Service by building the famous Roosevelt Dam, behind which can be stored 1 100 000 acre-ft. of water. With this water, about 200 000 acres of land will be irrigated directly, and power will be generated for pumping water to nearly 60 000 acres more. In addition, there is an excellent reservoir site on the Verde River above McDowell, and large tracts of land on the Gila River in the vicinity of Solomonville and of Florence, Ariz., are now irrigated.

Along the Colorado River itself there are storage sites at Bullhead Point and at another point about 6 miles above the Laguna Dam near Yuma, while there are irrigable lands between Mohave and Yuma aggregating some 400 000 acres.

Table 1 is a summary of the areas above Yuma which are now irrigated, in a technical sense, although much of this territory, no doubt, is watered in a very unsatisfactory manner.

TABLE 1.

District.	Acres.	Acres.
Colorado River direct	19 000	
Green River and tributaries	255 000	
Grand River and tributaries	305 000	
Fremont River	16 000	
San Juan River and tributaries	57 000	
Little Colorado River and tributaries	12 000	
Virgin River	16 000	
Gila River and tributaries	230 000	
Scattering (other tributaries)	7 500	917 500
ADDITIONAL IRRIGABLE LANDS ABOVE THE YUMA VALLEY.		
Above the Grand Cañon	450 000	
Colorado River Valley below Mohave	400 000	
The Gila Drainage Basin	400 000	1 250 000
IRRIGABLE LANDS IN THE DELTA.		
Yuma Project	90 000	
Imperial Valley in the United States	600 000	
Imperial Valley in Mexico	300 000	
Other lands in Mexico—east of the Colorado	200 000	1 190 000
Grand total		3 357 500 acres.

TABLE 2.—APPROXIMATE STORAGE POSSIBILITIES OF THE BASIN.

	Acre-feet.
Green River, including the Brown Park Reservoir site	3 000 000
Grand River, including the Kremmling Reservoir site	3 000 000
Little Colorado	50 000
Bill Williams Fork	100 000
San Juan	1 500 000
Virgin River	....
Gila River	2 500 000
Colorado, below Mohave and above Yuma	....
Total	10 150 000 +

It must be borne in mind that all the figures in Tables 1 and 2 are for developments which are theoretically possible, and they would have to be more or less seriously reduced to be correct for commercially feasible developments, on account of the excessive cost and the formidable character of the silt problem.

Discharge at Yuma.—Observations of the gauge heights of the Colorado River have been made by the Southern Pacific Company on its bridge at Yuma since 1878. The U. S. Geological Survey has maintained a gauging station at this point since 1895, using rating curves for discharge reductions until 1902, since which time careful current-meter observations have been made every 3 or 4 days. Table 3 contains the data thus collected for the 18-year period, 1894 to 1911, reduced to averages.

TABLE 3.—ANNUAL DISCHARGE OF COLORADO RIVER FROM 1894 TO 1911, INCLUSIVE.

Year.	Mean, in cubic feet per second.	Total acre-feet.
1894	7 400	5 390 000
1895	9 900	7 162 000
1896	9 000	6 515 000
1897	12 400	9 039 000
1898	9 100	6 581 000
1899	12 200	8 870 000
1900	9 400	6 798 000
1901	11 700	8 495 000
1902	8 400	6 127 000
1903	15 600	11 329 000
1904	13 900	10 119 000
1905	27 300	19 710 000
1906	26 800	19 475 000
1907	35 100	25 500 000
1908	18 900	13 700 000
1909	35 800	26 000 000
1910	19 700	14 335 000
1911	24 600	17 839 000
Mean	17 070	12 388 000

The minimum annual discharge was observed in 1894, and the maximum in 1909. The discharge has been strikingly greater since 1902 than for previous years, but too much dependence should not be placed on the data obtained prior to 1902, at which time very frequent current-meter observations were commenced. The lowest discharge was probably 2 400 sec-ft. in January, 1894, the average for that month being only 2 510 sec-ft.; the greatest was 149 500 sec-ft. on June 24th, 1909. The smallest total discharge for one month was 154 100 acre-ft. in January, 1894, and the greatest was 6 250 000 acre-ft. in June, 1909.

TABLE 4.—MEAN MONTHLY DISCHARGE OF COLORADO RIVER, 1894 TO 1911, INCLUSIVE.

Month.	Cubic feet per second.	Total, mean monthly, in acre-feet.
January	7 310	450 400
February	8 370	466 900
March	12 830	787 800
April	16 380	973 200
May	34 280	2 104 200
June	50 500	3 000 000
July	29 630	1 819 200
August	13 560	832 700
September	9 880	586 900
October	8 460	519 000
November	6 660	395 900
December	7 060	433 200
Totals	17 080	12 369 400

The record for 1908 is given by months in Table 5 as typical of the monthly variation. The lesser disturbances caused by the floods from the Gila in the autumn are very well shown; in this case, the maximum discharge from this source occurs in December, instead of from the Colorado in June.

TABLE 5.—MONTHLY DISCHARGE OF COLORADO RIVER AT YUMA, ARIZONA, FOR 1908.

(Drainage area, 260 000 sq. miles.)

Month.	DISCHARGE, IN SECOND-FEET.				RUN-OFF.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth, in inches, on drainage area.	Total, in acre-feet.
January	7 400	5 600	6 320	0.028	0.03	389 000
February	45 000	6 300	14 200	0.063	0.07	817 000
March	33 000	10 100	16 100	0.072	0.08	990 000
April	35 000	12 900	17 800	0.079	0.09	1 060 000
May	33 000	23 000	27 200	0.121	0.14	1 670 000
June	61 700	30 000	42 900	0.191	0.21	2 550 000
July	53 800	18 900	32 600	0.145	0.17	2 000 000
August	36 100	18 600	24 300	0.107	0.12	1 490 000
September	19 300	7 000	11 400	0.051	0.06	678 000
October	20 000	6 600	9 510	0.042	0.05	585 000
November	10 200	6 000	8 090	0.036	0.04	481 000
December	72 500	6 000	15 900	0.071	0.08	978 000
The year	72 500	5 600	18 900	0.084	1.14	13 700 000

Necessity for Storage.—The figures for the discharge at Yuma show that, in an ordinary dry year, the Colorado, without regulation, will serve not more than 500 000 acres. On the other hand, in an ordinary dry year, with fairly complete regulation—that is, with 2 000 000 acre-ft. of water storage—this river will serve 1 500 000 acres, and any supply held over from wet to dry years would add to the reserve. It is conservative to assume at present that no reservoir site on the Colorado below the Grand Cañon can be utilized, on account of the apparent absence of rock foundations for dams in the river, while, even if other things were favorable, the tremendous quantity of silt in the water means a heavy reduction in the reservoir capacity which could be obtained. Indeed, it has been seriously suggested that by the construction of a series of such dams, the silting up would in time create large areas of excellent land, one above the other.

Above the Grand Cañon, the Kremmling Reservoir site, on the Grand River, and the Brown Park Reservoir site, on the Green River, would together store approximately 4 500 000 acre-ft., and thereby add much more than 1 000 000 acres to the irrigable lands of the Arid West. When it is considered that the present irrigated area of Southern California, exclusive of the Imperial Valley, is less than 300 000 acres, the potentiality of storage along the Colorado is startling.

Another very important feature of water storage along the river is the marked effect it would have in decreasing the difficulty of controlling the Lower Colorado River. Levee construction and bank protection must obviously be designed to guard against maximum floods, and it is these which the storage basins would affect to the greatest degree. The completion of the Roosevelt Dam, which will hold back 1 100 000 acre-ft. on the Salt River, will in future undoubtedly reduce the dreaded floods from the Gila River.

Rise of the Bed at Yuma.—If the measured discharge of the river at various heights is used in making a rating curve, and this curve is extended back, by means of the gauge readings, to 1878, the results would indicate that the quantity of water formerly passing Yuma was materially less than at present. As a matter of fact, the average low-water plane has constantly risen, and a comparison of the gauge heights by 10-year periods beginning with 1878 shows the following average elevations:

1878 to 1889	114.5 ft.
1890 " 1899	116.6 "
1900 " 1909	117.4 "

The low-water plane at the end of 1909, however, was 3½ ft. lower than during any of the six preceding years, which included the period of diversion into the Salton Sea. Indeed, it was lower, by more than 1½ ft., than 20 years ago, and only 0.8 ft. higher than during 1878-79. The reasons for this interesting condition of affairs will be considered later.

Following conventional practice, the endeavor was made for a long time to establish a rating curve for the Yuma gauging station, but this was found to be impossible. The reason is that the bed is eroded during high water and silted up during lower stages, thus fundamentally changing the cross-section, not only for different gauge heights, but for the same gauge heights at the beginning and end of a high-water period. The reason for the exaggerated extent of such action is as follows: The Colorado at all times carries considerable silt, the quantity and character, of course, depending on the velocity of the water. Assuming a given discharge, and conditions of equilibrium, the bed of the river will have a given slope, the water will have a certain velocity, and will carry a certain quantity of sediment, none of which will exceed a definite size or specific gravity. If the volume of water increases, the water section and hydraulic radius will increase, and will result in greater velocity, which will give greater silt-carrying capacity. Conditions at the outfall or mouth are determined and temporarily unchangeable, therefore, it follows that the grade of the river will automatically tend to flatten itself by

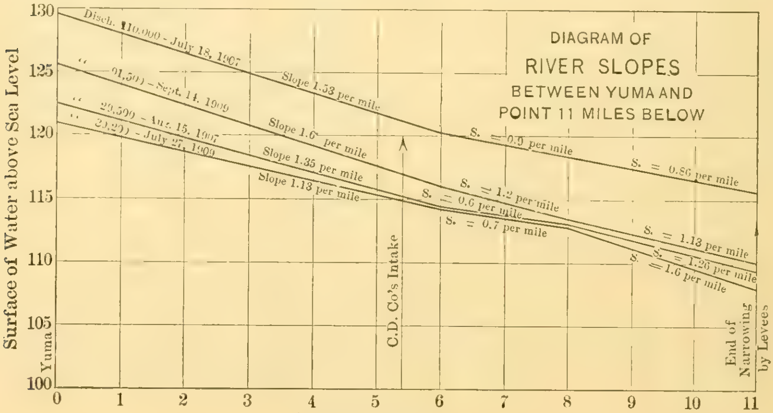
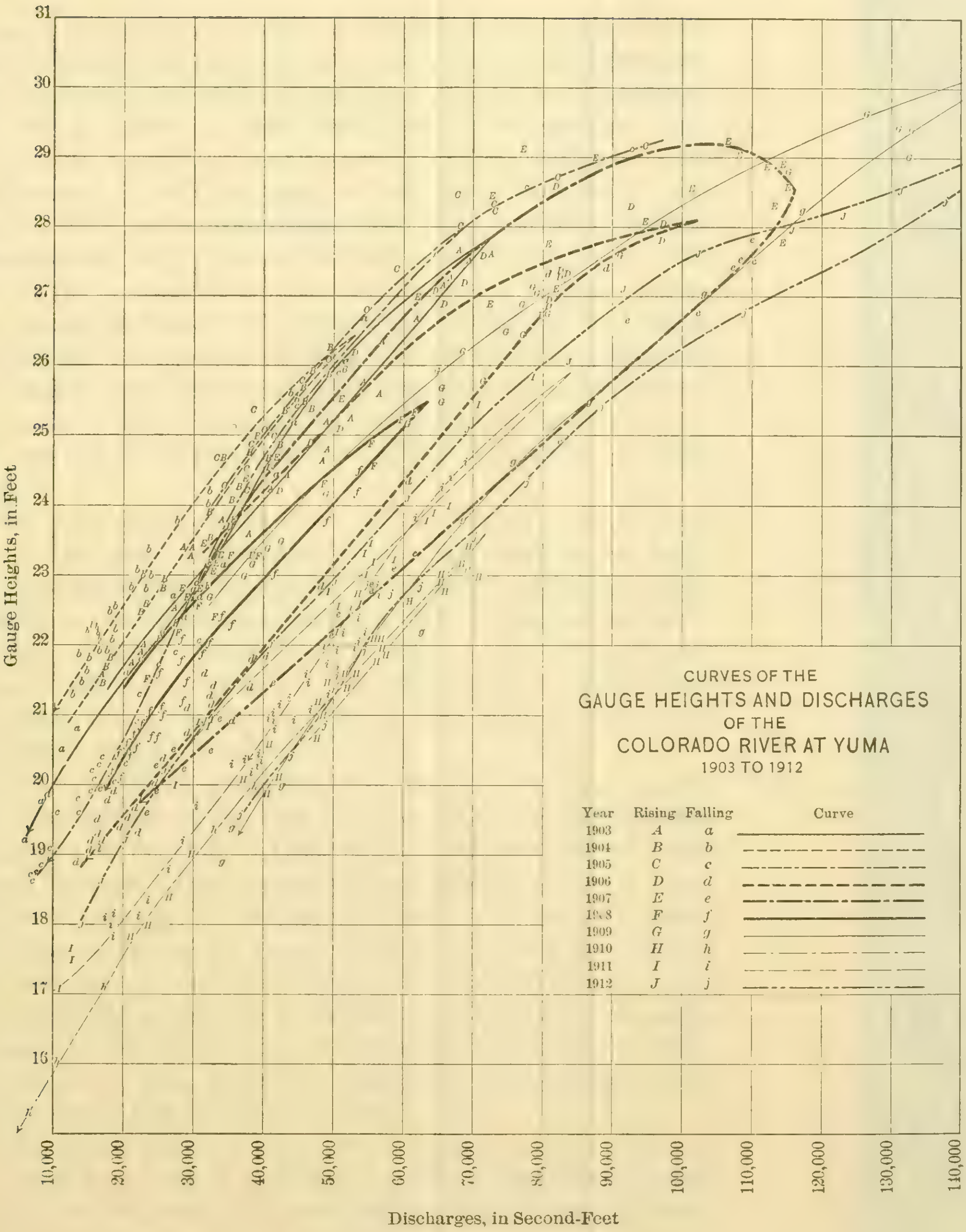


FIG. 2.

PLATE CI.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.



CURVES OF THE
GAUGE HEIGHTS AND DISCHARGES
OF THE
COLORADO RIVER AT YUMA
1903 TO 1912

picking up additional quantities of silt and carrying them along. When the volume of water decreases, the velocity will slacken, resulting in carrying less silt, and the bottom will rise with increasing slope until equilibrium is again established. This condition of affairs results in surprisingly great changes at Yuma during long periods of high water. In 1907 and again in 1909 it was found that for an increase of 10 ft. in the gauge height there was a lowering of the bed of approximately 30 ft., making the total increase in depth of water almost 40 ft. In other words, the grade line drawn from the bottom of the channel at Yuma to the average water surface in the Gulf of California had 30 ft. more fall, from Yuma down, at the beginning of the summer floods of 1907 and 1909, than when the peaks had just been passed. A few weeks after the first of these floods had entirely passed, the bed of the river had been restored to its usual low-water position.

When flashy floods occur, there is not sufficient time for this action to take place to a marked degree, and therefore the flashy rise of November 28th, 1905, having an estimated discharge of only 115 000 sec-ft., reached a gauge height of 31.3 ft., whereas the maximum discharge in the summer flood of 1909 was 149 500 sec-ft. and the gauge height was only 29.2 ft. In other words, the flashy floods do not have time to render the river channel more efficient before the maximum demand is made on it.

The increase in the gauge height of the low-water plane is due to the same general action. As the river builds the delta farther and farther into the Gulf of California, the bed must rise all along the line, of course, taking averages of considerable periods of time. According to Capt. J. H. Mellon, of Yuma, Ariz., who for a great many years navigated the Lower Colorado, the delta fan has extended out into the Gulf more than 6 miles in the past 40 years. Assuming the fall of the river in the lower reaches at 1.2 ft. per mile, the rise in the bed should average 1.2 ft. in 6⅔ years, or approximately 0.2 ft. per year. These figures are about what the hydrographs seem to show, namely, 2 ft. per 10-year period.

Effect of 1909 Flood.—The fact has been mentioned that the low-water plane at the end of 1909 was only 0.8 ft. higher than during 1879, and this becomes much more striking when the general elevations for the entire period are shown by a curve. There were two factors which tended to produce such a result: first, the diversion of the river through the Abejas to the west during the summer flood of 1908, and the lowering of the river bed at that point; and second, the effect of the Laguna Weir basin, which existed as such for the first time that year.

It seems very probable that the Abejas diversion was the smaller influence, in spite of the fact that at the time it was generally considered to be the only factor of importance. Undoubtedly, the bed of the river, and consequently the surface of the water, lowered rapidly while the diversion was becoming an accomplished fact. The amount of such lowering could not have been more than a very few feet at most, although it probably seemed much greater to nervous and frightened observers.

Doubtless it was an important factor that the Laguna Weir had been completed just before the beginning of that year's summer flood, and created a reservoir having a capacity of perhaps 20 000 acre-ft. The waters of the Colorado, heavily laden with silt, were here stilled and their contents deposited. The large volume of water which passed over the dam—the greatest ever recorded on the river itself—contained little more silt than it would ordinarily during low-water stages. Consequently, it picked up and carried along the silt to an unprecedented extent. As the waters receded, the bed was built back to a very much less extent, because there was still an extraordinarily small quantity of silt in the water. Indeed, during this one season, the basin formed by the Laguna Weir was completely filled and some 20 000 acre-ft. of mud were deposited out of the Colorado at this point instead of being spread along the river bed thence to the Gulf.

Unfortunately, no sediment observations were made at Yuma during this flood period. Had this been done, the influence of the Laguna Basin on the low-water plane would doubtless have been approximately ascertainable. In any event, the gauge heights at Yuma, for discharges of 30 000 and 10 000 sec-ft., respectively, platted as ordinates, with the times as abscissas, as in Fig. 3,* for the period of 1902 to 1912, show very clearly that there has been no serious grade recession at Yuma due to the Abejas diversion.

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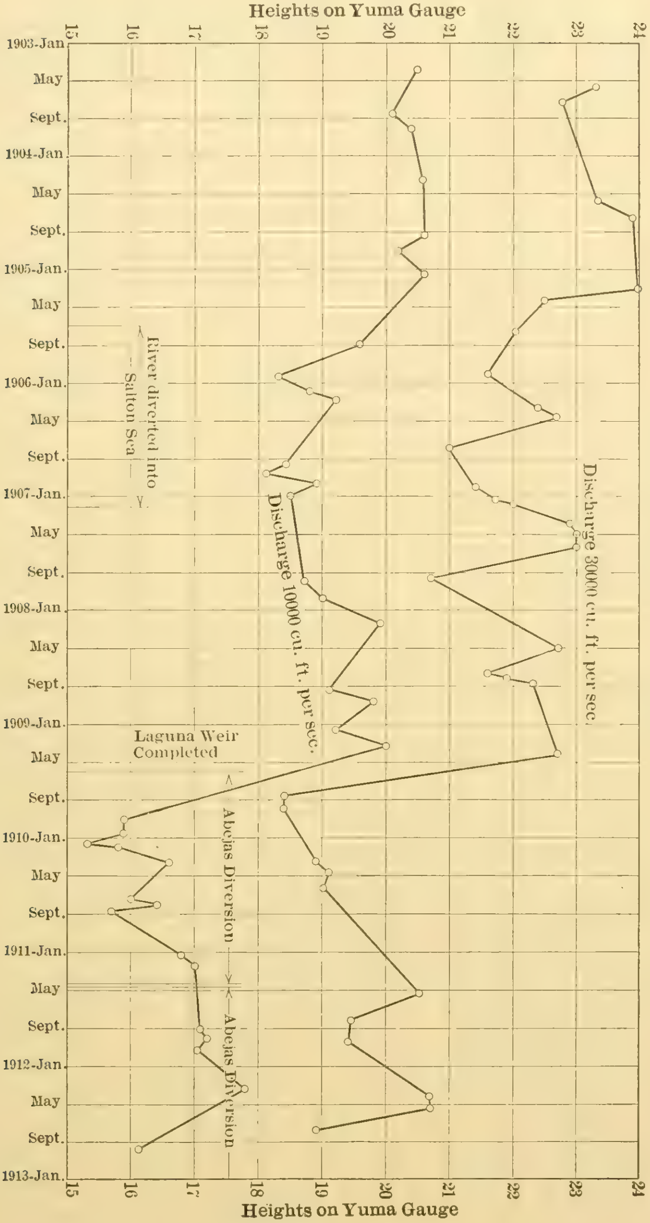
* This method of platting seems to be the only one possible to show much relation, if any at all, between gauge height, discharge, and time at the Yuma gauging station.



GAUGE HEIGHTS OF COLORADO RIVER AT YUMA FOR DISCHARGES OF 30000 AND 10000 CU. FT. PER SEC. JANUARY, 1903, TO JUNE, 1912.

Fig. 3.

Silt.—Professor C. B. Collingwood, of the University of Arizona Agricultural Experiment Station, examined the silt contents of the Colorado River water at Yuma for a period of 7 months, beginning with August, 1892. One pint of water was taken each day and evaporated, and the sum of the daily residues for each month was then weighed and analyzed. The results varied from a minimum of 1 part of sediment to 613 parts of water in January, 1893, to a maximum of 1 to 97 in October, 1902, and an average of 1 to 388, the ratio of dry material to weight of water being 1 to 277. The corresponding ratio in the Mississippi is 1 to 1 500; the Nile, 1 to 1 900; the Danube, 1 to 3 060. The average value of the fertilizing material was computed at $3.22 per acre-ft.*

Later, January 1st to December 31st, 1904, Professor R. H. Forbes, now Director of the same Experiment Station, made a careful study of the quantity of silt,† and the relation of irrigating sediments to field crops.‡ It was found that the quantity of silt varied from 84 to 3 263 parts per 100 000 by weight, and from 250 to 9 800 parts per 100 000 by volume, or roughly $\frac{1}{1\,200}$ to $\frac{1}{30}$ part by weight, and that 1 acre-ft. of river water contained from a minimum of 1.14 tons to a maximum of 44.42 tons, and an average of 9.62 tons, of silt. Obviously, the total quantity of sedimental material cannot be obtained by multiplying the average sedimental contents by the total annual discharge, but the investigations were carried out in such detail that it was possible to compute the quantity of solid material from the discharge at the time, and in this way it was found that the total solid material carried past Yuma that year was 120 961 000 tons. The total discharge of the river during that year was 10 119 000 acre-ft., while the annual average for 1894 to 1911, inclusive, was 12 388 000 acre-ft. It would seem conservative to estimate that the average quantity of material would be as much larger than that delivered in 1904 as the discharge, on which basis the result would be $120\,961\,000 \div 10\,119\,000 \times 12\,388\,000 = 148\,084\,000$ tons. The specific gravity of the Colorado sediment is 2.65 and the weight of dry soil is 93 lb. per cu. ft., so that this quantity of material would make approximately 71 800 acre-ft. or 112 sq. mile-ft. of equivalent dry alluvial soil.

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* These results are given in Bulletin No. 6 of the Arizona Agricultural Experiment Station.

† Bulletin No. 44.

‡ Bulletin No. 53.

Navigability.—In a technical sense, the Colorado River is navigable from its mouth up to Laguna Dam, and again from there to The Needles. This navigability was recognized when Mexico and the United States entered into the treaty of 1848 regarding the International Boundary Line. By the provisions of this treaty, neither country was to permit works which would interfere with navigation throughout that part of the river which is a common boundary. In a subsequent treaty (1853) this provision was abrogated, but the United States guaranteed in lieu thereof a free and uninterrupted passage of vessels and citizens as far as the river forms a common boundary. As a matter of fact, the swift, shoal waters and the shallow depth over bars in the river itself, together with a tidal bore at the mouth, where the range of tide exceeds 30 ft., has resulted in practically no commerce on the river below Yuma since the Southern Pacific Railroad completed its track in 1876. At various times the U. S. Army engineers have investigated the situation, but have always reported that the navigation interests were not sufficient to justify any expenditure for river improvement.

An Act approved April 21st, 1904, authorized the Secretary of the Interior to divert water from the Lower Colorado River for irrigation purposes and to construct a diverting weir across the river at The Potholes, or Laguna, in which no provision whatever is made for navigation.

Delta of the Colorado.

The Delta of the Colorado River of the West, at the head of the Gulf of California, lies approximately between the parallels of 32° and 33° N. and the meridians 114° 30′ and 115° W. It is partly north of the International Boundary Line between the United States and Mexico, and in larger part south of that line. Its area, including the Pattie Basin and the Cocopah Mountains, is approximately 6 000 sq. miles. It extends practically from the mouth of the Gila River, at Yuma, westward to the rocky walls of the San Jacinto Mountains and south to tide water of the Gulf, while on the north it blends with the depressed area below the sea-level, from which the ocean has been cut off by the deposits of the stream. Its general deltoid form is shown on Fig. 4, together with the course of the main stream and principal branches, sloughs, and overflow channels.

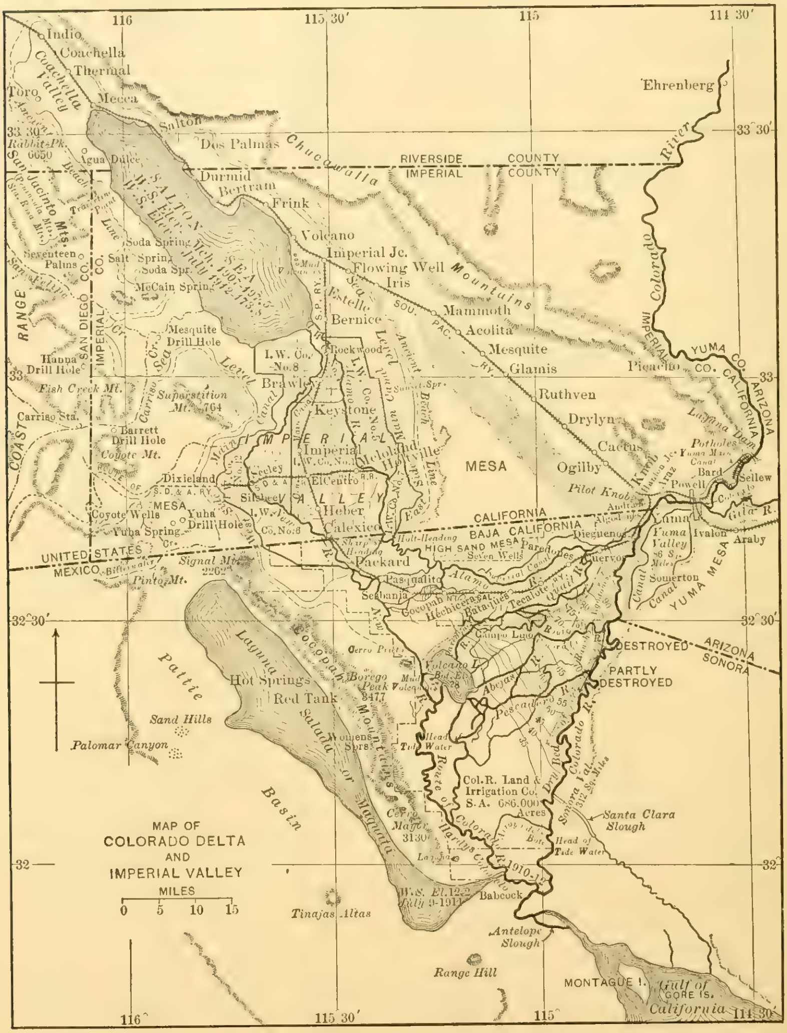
MAP OF
COLORADO DELTA
AND
IMPERIAL VALLEY
MILES
0 5 10 15
116
115 30′
115
114 30′
33 30′
33
32 30′
32
Indio
Coachella
Thermal
Coachella Valley
Toro
Mecca
Salton
Rabbit Pk. 6050
Agua Dulce
San Jacinto Mts.
Dos Palmas
Chuckawalla
RIVERSIDE COUNTY
IMPERIAL COUNTY
Durmid
Bertram
Frink
Volcano
Imperial Jc.
Flowing Well
Iris
Mountains
Soda Spring
Salt Spring
Soda Spr.
McCain Spring
Seventeen Palms
SAN DIEGO CO.
IMPERIAL CO.
RANGE
COAST
SALTON SEA
Mesquite Drill Hole
Hanna Drill Hole
Fish Creek Mt.
Superstition Mt. 764
Carrizo Sta.
Barrett Drill Hole
Coyote Mt.
Dixieland
S. D. & A. RY.
MESA
Coyote Wells
Yuha Drill Hole
Yuha Spring
UNITED STATES
MEXICO
Signal Mt. 2262
Pinto Mt.
Ehrenberg
Colorado River
Estelle
Bernice
Mammoth
Acolita
Mesquite
Glamis
SOU. PAC. RY.
Rockwood
I. W. Co. No. 8
Brawley
Keystone
IMPERIAL VALLEY
Imperial
Meloland
Holtville
Seeley
El Centro
Silsbee
Heber
Calexico
MESA
Ruthven
Drylyn
Cactus
Ogilby
Pilot Knob
Picacho
YUMA CO.
CALIFORNIA
ARIZONA
Laguna Dam
Potholes
Yuma Mesa Canal
Bard
Sellew
Gila R.
Yuma
Yuma Valley
Ivalon
Araby
Somerton
YUMA MESA
CALIFORNIA
BAJA CALIFORNIA
HIGH SAND MESA
Seven Wells
Packard
Pasqualito
Sesbania
Alamo R.
Cocopah Mts.
Paredones
Cuervo
Campo Lugo
DESTROYED
PARTLY DESTROYED
ARIZONA
SONORA
Laguna Salada
Hot Springs
Red Tank
Cerro Prieto
Volcano L.
Borego Peak 3477
Pescadero
Abejas R.
Pattie
Sand Hills
Palomar Canyon
Basin
Womens Sprs.
Head Tide Water
Col. R. Land & Irrigation Co. S. A. 686.000 Acres
Santa Clara Slough
Colorado R.
Cerro Mayor 3130
Hardy's Colorado
Route of Colorado R. 1910-11
Head of Tide Water
Babcock
Tinajas Altas
Antelope Slough
Range Hill
MONTAGUE I.
GORE IS.
Gulf of California

FIG. 4.

The Lower Colorado River.—The Lower Colorado River may be considered as that portion lying below the last narrows, at what is known as The Potholes—the location of the Laguna Dam, of the United States Reclamation Service. At this point the river debouches upon the plain, and the valley on each side is bounded by diverging mesas. About 13 miles below, and just above Yuma, the Gila River joins it. The present location of this portion of the river is shown on Fig. 5.

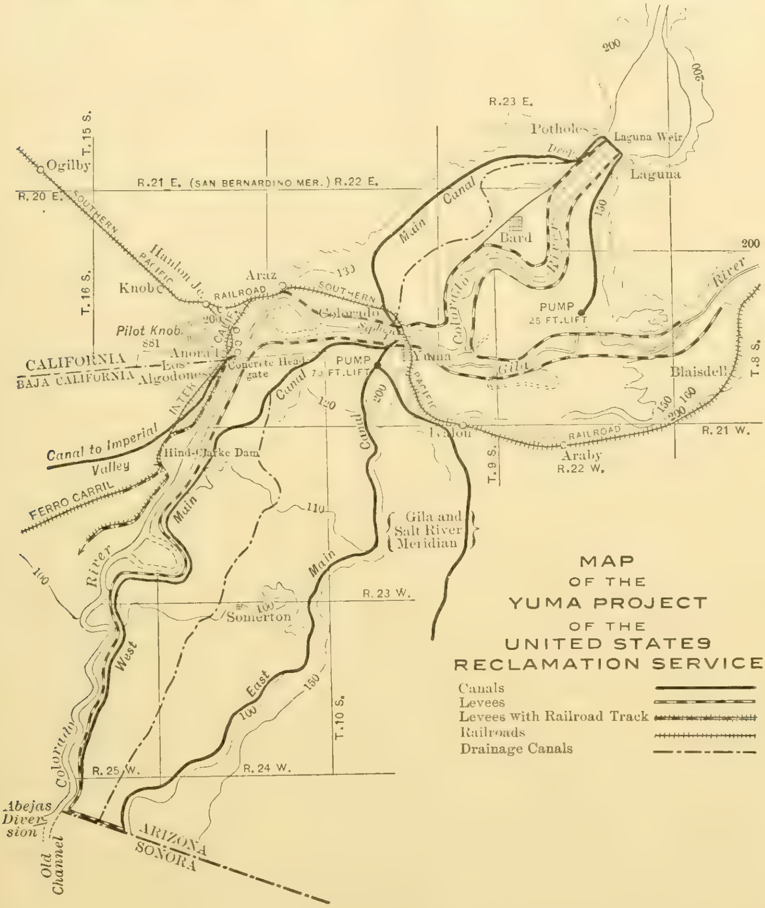

FIG. 5.

Alignment.—Below The Potholes there are two controlling points: one is a peculiar knob of indurated clay at Yuma through the center of which the river channel has passed since the first advent of the whites; the other is the granite hill known as Pilot Knob. The small eminence at Yuma covers about 40 acres, and reaches a height of not more than 100 ft. above the general level of the delta plain. A similar though much smaller knob lies on the east bank of the river, about 1 000 yd. below and just to the south of the Southern Pacific Railroad Company's line and bridge, and is occupied by the reservoir and settling basins of that company. These peculiar topographical features control the river, with respect to its location at Yuma, and at Andrade, at the International Boundary Line, 8 miles farther down.

Grade.—The course of the river is quite winding, like every flashy, silt-bearing stream with a relatively steep grade. The elevation at The Potholes is approximately 140 ft. above sea level, and the distance by the river is about 100 miles to the head of tide-water and 114 miles to the mouth at the Gulf. Thus the general average fall is approximately 1.3 ft. per mile.

Remarkable Vegetation.—Attention must be called to the dense and varied vegetation throughout the region subject to the river's overflow. Arrow weed grows in nearly impenetrable jungles; mesquite and screw-bean trees occur in forests of varying density on older established soil, while freshly deposited mud flats and banks are almost immediately covered with seedling willows which quickly grow into heavy timber. For instance, Professor Forbes counted on an area 5 ft. square 1 500 willow sprouts up to 20 in. high, and in another older growth 90 young willow trees 20 ft. high.* Cottonwoods occur, but are not abundant. Along the river banks and sloughs there are dense thickets of common wild cane, which the Mexicans call *carrizo,* with a densely matted root stock which affords great resistance to erosion of the soil because the plant spreads both by means of these root stocks and by sending long slender stems or runners across the mud flats to distances of 20 or even 30 ft., and these strike root at every point, thus rapidly establishing the plant on newly made ground. In marshy locations are found great fields of a plant with an immense edible bulb used by the Cocopah Indians as a food, locally known as *tule.* In addition there is the *sesbania,* or so-called wild hemp, which is limited strictly to ground subject to overflow. It comes up from seed annually after the subsidence of the summer floods, stands in dense thickets from 5 to 20 ft. high, and is often square miles in area. This plant is also of interest because of its industrial possibilities. In general, the vegetation of the delta is remarkable for the manner in which plants of a kind mass together in areas almost to the exclusion of other species, and for the remarkable density and immense areas occurring in continuous bodies, strips, and patches, particularly of willow, arrow weed, wild hemp, and *carrizo*.

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* "The Lower Courses of the Colorado," R. H. Forbes, in *The Great Southwest*, Yuma, Ariz., Vol. 1, Oct., 1906, p. 2.

Line Changes.—The entire Colorado River Delta has been said to consist of alluvial silt. When the river is low the water wanders in a devious way, along a very wide shallow bed in many places, and is everywhere confined by banks seldom exceeding 10 or 12 ft. high. During high stages these banks are overflowed at many points, and in the case of severe floods such overflow is practically general. The banks are thus wet and softened, and, when the river falls, caving and side-cutting proceed wherever the current is thrown at an angle against the confining banks, and often with startling rapidity. At the same time, the overflow water, being very heavily charged with silt, is checked by the dense, matted growth, and at once deposits its heavier particles, the smaller sizes being dropped a little farther down stream, and so on. Thus the country is built up most rapidly at the banks, and the land slopes away from the river at a constantly decreasing rate. Indeed, the theoretical cross-section of the land surface away from the stream is a hyperbola. Of course, these slopes are not identical at any two points along the river, but instrumental data at present available show the general average fall to be about 1½ ft. in the first 100 ft.; 3 ft. in the first 300 ft., and from 5 to 8 ft. in the first 3 000 ft.

Although the coarser silt deposits are thus found immediately at the river bank, there are several reasons why this has little practical significance. The overflow water gathers in little channels which follow the line of greatest slope and in general approximately away from and down stream, the direction being the resultant of the general grade parallel to the river, and of the slope locally from the river's banks to the abeyment on either side. Such overflow channels build up their miniature beds and banks exactly like the main channel; they join to form overflow creeks, and these in turn form the overflow rivers.

As the level of the river rises higher and higher by such overbank deposition, it is obviously only a question of time until an unusual flood will produce sufficiently high velocities in some of these overflow channels to cause a recession of their grades extending through the river bank, thus diverting a portion of the water through the new route. Ordinarily, as the flood recedes, such breaks are clogged with drift and sediment, but sometimes the clogging action is not rapid enough to counteract the opposing forces successfully, and in this way radical and extensive changes of the river's course throughout the delta occur. Usually, these changes are in the nature of cutting off bends and thus shortening the channel.

At first thought it would seem that a diversion to the west would be a very probable occurrence during any great flood, because, with the constant extension of the delta southward, the gradient in that direction has become less, and to the west, more, until the fall toward the Gulf is much less than half as great per mile as that along former courses to the Salton Basin. As a matter of fact, however, though the overflow waters go down these channels with considerable rapidity, the cross-sections for many miles from the river are exceedingly inefficient, due to the dense vegetation, drift in the water, and occasionally, no doubt, to beaver dams.

In addition to the foregoing, there is another factor of importance: The bed of the main stream for quite a distance on each side of the International Boundary Line is excessively eroded during flood periods and filled up during lower water stages, as has been fully explained, so that, with a given flood discharge in the river, the water going over bank constantly decreases in quantity, in depth, and in velocity, and it is only the overbank flow which is important in connection with the overflow channels.

Character of Local Silt Deposits.—These various actions result in the formation of numerous little pockets throughout the inundated areas, in which water is left standing after the recession of each flood. Wherever this occurs the very finest of the silt settles out and, on becoming dry, cracks in large, somewhat hexagonal, irregular cakes. If the deposit is very thin, these cakes curl up when thoroughly dried and are broken up and carried away as dust by the wind; but when very thick the cracks are sometimes 6 in. and even more in width at the top and extend down 4 or 5 ft. Dust and vegetation accumulate in

PLATE CII.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.

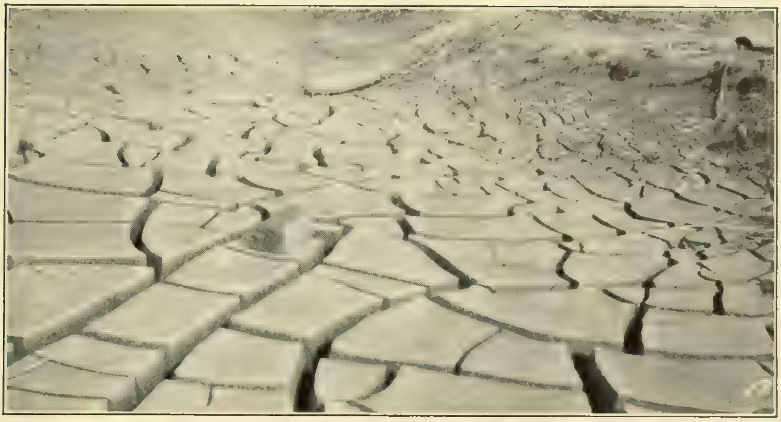

FIG. 1.—TYPICAL SURFACE OF CRACKED ADOBE SOIL.

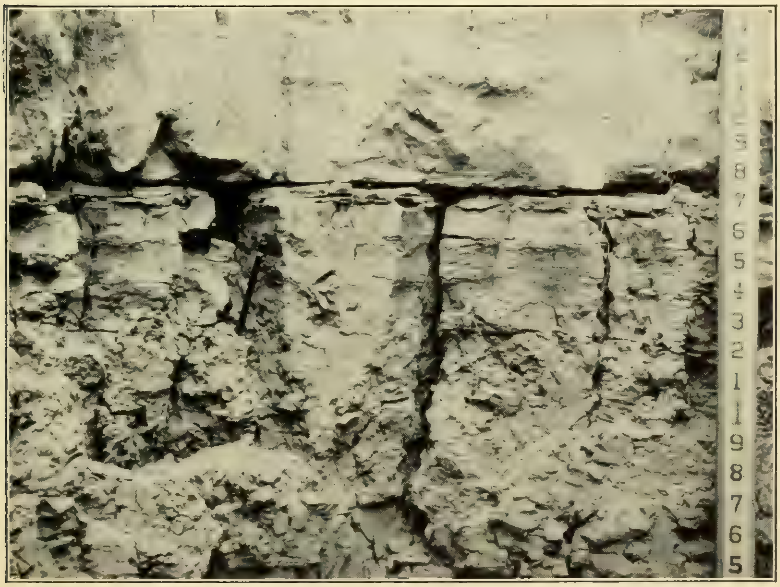

FIG. 2.—TYPICAL SUBSURFACE OF CRACKED ADOBE MATERIAL. THE BOTTOM OF THE ROD IS 5.3 FEET BELOW THE SURFACE.

such gaping cracks, and the next flood deposits another layer of sediment. Then, the heavier materials having settled first, the result is that the pockets are arched over, thus producing underground interstices which must be carefully guarded against in levee and other earth construction for holding back water.

The character of such deposits depends on the nature of the silt carried in the overflow water, and thus it happens that it is usually possible by examination to determine whether a deposit was made by a flood from the Colorado, or from the Gila proper, or from the Salt River.

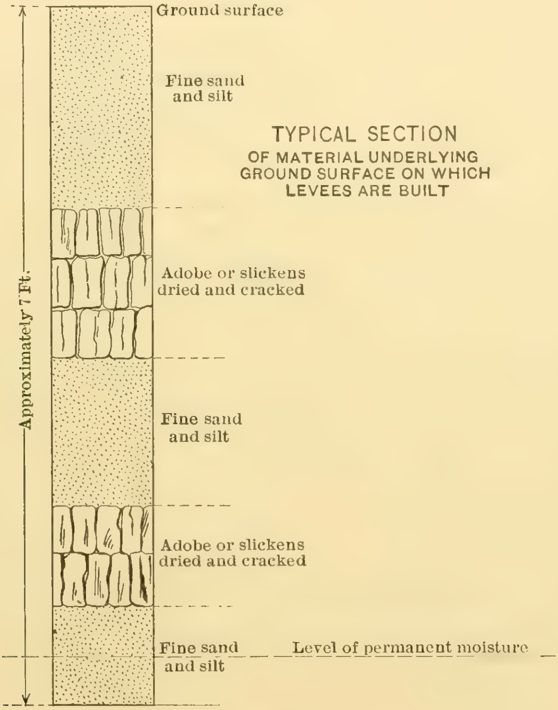
Ground surface
Fine sand and silt
TYPICAL SECTION
OF MATERIAL UNDERLYING GROUND SURFACE ON WHICH LEVEES ARE BUILT
Adobe or slickens dried and cracked
Fine sand and silt
Adobe or slickens dried and cracked
Fine sand and silt
Level of permanent moisture
Approximately 7 Ft.

FIG. 6.

The rate of such local deposition is sometimes startling. One instance the writer observed was due to the flood of 1905 which caused the diversion of the river into the Salton Sea. This filled in the ground on the left-hand side of the break about 3 000 ft. from the old river bank over quite an area to a depth of 6 ft., or almost to the roof of an Indian's *ramada*. In this manner the Colorado River.

from its exit from the Grand Cañon near The Needles, Cal., to about 3 miles south of Yuma, Ariz., has wandered about between its eastern and western abeyments, and, where these were any distance apart, has built up alluvial valley stretches which are practically level transversely.

The Principal Overflow Channels.—The overbank flow of the Colorado on the east side does not gather into channels of importance because the eastern abeyment is near by, except far down the stream, where there is what is known as the Santa Clara Slough. This, doubtless, at one time was the river's main channel, and during the severe summer flood of 1907 it carried so large a volume of water that for a time it seemed probable it would again become the main outlet of the river to the Gulf. This slough is about 40 miles long, and empties into the Gulf about 20 miles southeastward from the present mouth. This and the other smaller high-water channels on the east side are of no material importance in the engineering operations along the river.

By far the greater portion of the delta cone lies on the west side, where there are five inundation channels of considerable importance. These are shown on Fig. 4. In their order down stream from Andrade, they are known as the Alamo, New Paredones, Abejas, and Pescadero Rivers. Without a thorough knowledge of them and their relationship to the Colorado flood-waters, no satisfactory understanding of the problems of the Lower Colorado, and the endeavors to handle them, is possible.

The Alamo River, which was formerly often called the Salton or Carter's River, has its gathering ground in the northerly edge of the delta cone immediately south of Andrade. It follows somewhat closely the southern end of the sand hills, at times in a well-defined channel and again spreading out in broad swamp sections, known locally as lagunas. About 40 miles west of the Colorado it crosses the International Boundary Line, and occasionally its waters were doubtless carried clear into the Salton Sink. The swamp areas, *Las Lagunas,* were also drained in part by the Quail River, which emptied into the Paredones. Farther down the Alamo there is a low area to the south and west through which the overflow waters from the great flood of February, 1891, broke over from the Alamo into the New River, the main point being at what is known as Beltran's Slough. The latter runs into the low region between the Paredones and the Alamo, and this drains into New River through the Garza Slough. It seems probable that in 1891, for the first time in many years, the overflow waters reached the New River channel directly *via* the Alamo, rather than *via* Volcano Lake. During this flood from the Gila and the later annual summer flood of the Colorado, sufficient water reached the Salton Sea *via* the Alamo and the New Rivers to cover approximately 100 000 acres in the bottom of Salton Sink to a depth of about 6 ft., and it is estimated that the discharge of both these rivers aggregated 17 000 sec-ft. for a period of several weeks. Well-defined channels in the soft alluvial soil were cut out by both these streams, and since then the New River has carried some water every flood season, as it did occasionally before.* In July, 1903, it reached a maximum of only about 4 000 sec-ft., which was then the largest since 1891.

New River really heads in Volcano Lake, and probably is what remains of an overflow channel through which the ancient inland lake, Lake Cahuilla, emptied into the Gulf of California. At present its grade is to the north and into the Salton Basin, and from the lake's edge it follows for some miles the base of the Cocopah Mountains until it reaches about the + 10-ft. contour, where the mountains turn rather sharply to the west. The river continues in a general northwesterly direction and crosses the International Boundary Line at Calexico, where, until the recent tremendous erosion due to the diversion of the Colorado River into the Salton Sea, it followed a gentle depression down the lowest median line into the Salton Sink. At a few places in its course it spread out into broad channels, a few feet in depth, and formed occasional ponds or lakes, the most important of which were the Cameron Lake, near Calexico, Blue Lake, a few miles farther northwest, and Pelican Lake, a few miles farther on. It is now a great barranca, averaging from 40 to 80 ft. in depth and 1 000 ft. in width, from a point about 6 miles southeast of Calexico to the Salton Sea.

The Paredones is the first drainage channel on the southerly slope of the delta cone, and within quite recent years had direct connection with the Colorado River. This connection was automatically reduced to the very small channel which existed in 1906, when the levee construction then done fundamentally changed overflow conditions. The Paredones gathers the overflow water from a large area, and a few miles from the river becomes a channel of considerable width and depth, following thence along down an element of the delta cone. During the extraordinary conditions existing in 1905-06, it carried a very large quantity of drift, which, with the assistance of some beaver dams, accumulated about 7 miles above Volcano Lake, and resulted in enlarging the branches leading toward the south. The overflow water of this river gathers to the south in the Pescadero, and to the north joins with the similar water from the Alamo and runs in part to Volcano Lake and in part through Garza Slough to New River.

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* Old settlers in the vicinity agree in saying that in 1840, 1849, 1852, 1859, 1862, and 1867 large quantities of water reached the Salton Sea. In 1862 that body of water attained unusual size, and the flow in New River that summer was so great that it stopped the mail stage-line service between Yuma and San Diego for several weeks, and a flatboat was built to ferry across it.

The Abejas River drains the overflow from the region immediately south of the Paredones, and empties into the western side of Volcano Lake. Since the summer flood of 1908, this channel has been carrying the entire low-water flow of the Colorado and the greater portion of the flood flow, which is the condition to-day. The reasons for this diversion and the efforts to stop it will be considered at length later.

The Pescadero, another important overflow channel, drains the region immediately below that unwatered by the Abejas. It empties into a network of channels which conduct the water from that part of the delta cone and including Volcano Lake, finally gathering into Hardy's Colorado and emptying into the Gulf.

Volcano Lake may be another remnant of the waterway through which the ancient Salton Sea drained to the Gulf. It is a flat basin, the bottom of which is about 22 ft. above sea level, and its high-water stage is about 35 ft. At such a stage it extends about 10 miles northwest and southeast, and is about 6 miles wide. It is fed by the Paredones and Abejas Rivers, the latter since 1908 being the course of the Colorado proper, and by the system of sloughs which form the Pescadero network and also serve as an outlet. It is on the summit of the low, flat divide between the Salton Basin on the north and the Gulf on the south, and thus its discharge is both toward the north and the south. From the size of the outlet channels it is obvious that the greatest discharge has in recent times been southward. Since 1908 a line of levees has prevented any water from passing into the New River and thence into Salton Sea; the lake's waters, therefore, go to the Gulf through Hardy's Colorado, which is an important channel, averaging perhaps 500 ft. wide and 20 ft. deep at maximum stages, with a fall varying with the stage in the lake from less than 15 to more than 30 ft. in a distance of from 45 to 50 miles.

The engineering operations which resulted in the irrigation of the Imperial Valley and its threatened destruction by inundation at various times since, have in very large measure been concerned with the overflow channels just described.

Diversion to the West.—Regardless of the tendencies for and against a fundamental diversion toward the west, the Colorado continued to flow in its regular bed to the Gulf until 1905. There can be no doubt that the operations of the California Development Company, and particularly in making an artificial cut from the Colorado River into the Alamo Channel and the utilization of that channel as a main canal, rendered the diversion to the west at that point, when it broke through in 1905, very much easier and more probable of immediate occurrence. Nevertheless, the behavior of the river since that time indicates pretty clearly that a diversion to the west somewhere within the first 25 miles below Pilot Knob was just about due, under natural forces alone. The conditions of equilibrium had become unstable to a degree, and this is the condition in which they are to-day.

Mesa and Delta.—The high mesa land which forms the eastern abeyment below Yuma extends therefrom almost south and into Mexico. The river turns, crossing the valley almost from east to west for about 5 miles, until it reaches the foot-hills forming the west abeyment; then it turns more than a right angle, hugging these hills, to the International Line; and thence it flows for 80 miles, in a remarkably direct general line, but little west of south, to the Gulf. On the west side of the valley the foot-hills end at Pilot Knob, a small mountain at the International Boundary Line, and the low mesa begins. The edge of the latter runs southwest for 4 miles; then it turns sharply directly west for 25 miles; then again it turns sharply to a little west of north for 50 miles—the latter edge forming the east side of the cut-off portion of the Gulf, Lake Cahuilla.

It is thus in a sense almost proper to say that the Colorado Delta begins practically at the International Boundary Line between California and Lower California, and that, for the first 14 miles below that line, the river is running on the very edge of the divide of the delta cones, on one side sloping northwest to the Salton Sea and on the other to the Gulf. Furthermore, from that point the river (until 1908) was in a ridge of its own making, which it was raising constantly, and which is quite close to the eastern abeyment.

Pilot Knob.—Pilot Knob is a small, detached, and relatively abrupt mountain lying just above the International Boundary Line on the west bank of the river, and is one of the landmarks of the region. One of its rocky arms extends almost to the present west bank of the river. Fifty years ago the river had a pronounced bend, shown by the dotted line on the map, Fig. 5, and hugged this rocky point until passing it. The time when the shift of the river took place is not definitely known, but, very fortunately, at present the alignment here for several miles is almost straight.

It is quite significant that Pilot Knob is the lowest point along the river where a canal can be taken out for the diversion of water, with the diverting structure resting on solid rock. For this reason, it has been considered as a strategic factor in the irrigation of the Imperial Valley, but, in the writer's opinion, quite erroneously. The engineering fetish of a solid rock foundation for structures for irrigation and other purposes confining water, has resulted in needlessly spending amounts of money in the United States alone which must aggregate a tremendous sum. Perhaps no case is more spectacular than that of Pilot Knob and its relation to the irrigation system of Imperial Valley.

Early Suggestions Regarding Salton Sea.—Almost the very first explorers were interested in the Salton Basin and its various possibilities. The ability to create an inland sea by diverting into it the water of the Colorado attracted much attention, and it was very seriously suggested because of a supposed advantageous effect that it might have on the climate of the entire region. On the other hand, the possibilities of irrigating the Colorado Desert by the waters of the Colorado, which has since been accomplished, were not overlooked, work having been done on many more or less serious propositions at various times.

LATER IRRIGATION PROJECTS.

In 1891 and 1892, the Colorado River Irrigation Company was formed. Mr. C. R. Rockwood was placed in charge of the engineering work, and, under his direction, the entire problem of irrigating the Colorado River Delta was carefully examined and the important features fully worked out. The financial stringency of 1893 put an end to the operations of this corporation, and in 1894 Mr. Rockwood, was forced to sue the company for his unpaid salary. In partial satisfaction of the judgment which he obtained, the engineering records and data were taken over by Mr. Rockwood, and the Colorado River Irrigation Company ceased to exist. Nevertheless, it is interesting to consider the plans then evolved by that corporation, or, more properly speaking, by its engineer, Mr. Rockwood.

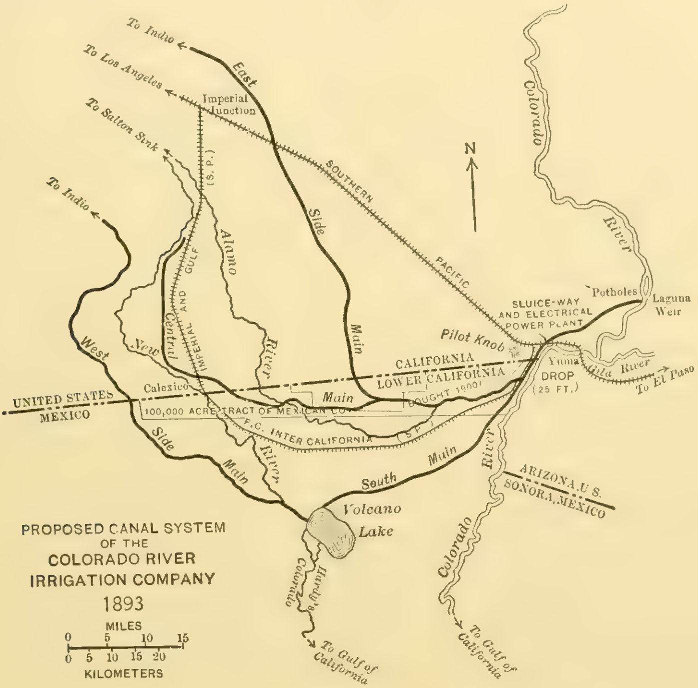

FIG. 7.

Plans of the Colorado River Irrigation Company.—These plans are outlined diagrammatically in Fig. 7, and show what is probably the ideal system of diversion and canals for watering all the land irrigable by gravity with the waters of the Lower Colorado. Events, however, shaped themselves so that the water for Imperial Valley has been, and is now being, diverted at Pilot Knob; while the U. S. Reclamation Service has built a diversion weir at The Potholes or Laguna to put water by gravity on all except the mesa lands in the so-called

Yuma Valley. Mr. Rockwood contemplated taking water out at The Potholes and installing in the main canal near Pilot Knob a sluice-way with which he intended to flush out the silt in the canal above, which escaped being deposited in and removed by hydraulic dredges from a short enlarged section of the main canal immediately below the diversion point, where the velocity of the water would be reduced. The dredges were to be operated by electricity generated at the sluice-way. The maps showing the detailed surveys of these canals are now in the files of the California Development Company at its Calexico headquarters.

The California Development Company.—Mr. Rockwood, being thoroughly imbued with the practicability and advantages of the project to irrigate the Imperial Valley with the waters of the Colorado, undertook to carry it through, and finally did so by means of the California Development Company. At the present time it is only important to say that, because of financial considerations, the engineering features were radically modified to diverting the water at Pilot Knob and utilizing a large part of the Alamo overflow channel as a main canal to carry the water around to the Imperial Valley, essentially as suggested by Lieut. Bergland in 1875-76. In this way the diversion work at The Potholes was eliminated, and a very cheap and quick method of getting water into the valley was arranged. By this decision the inclusion of the Yuma Valley as a part of the project was abandoned.

The Yuma Project, U. S. Reclamation Service.—As early as 1895 the Hydrographic Branch of the United States Geological Survey began stream gauging in California, starting with an allotment of $5 000. More recently, the California Legislature has aided in the work on the basis of appropriating sums equal to those set apart by the United States. At the present time daily discharge observations are made on about fifty typical streams. Hydrographic investigations throughout the Western States, not only helped to prepare the way for national irrigation, but resulted in acquiring such hydrographic data that when the Reclamation Act was passed, in 1902, the best opportunities for national irrigation projects were pretty generally outlined. On account of legal and social complications elsewhere throughout California, the Yuma Project was finally selected as the first to be commenced by the Reclamation Service in that State. On April 8th, 1904, a board of seven engineers recommended this project; on April

21st, Congress authorized the Reclamation Service to take water from the Colorado and divert it by a weir which would close it to navigation permanently above Yuma. On May 10th, 1904, the Secretary of the Interior gave his approval, and an allotment of $3 000 000 was made.

There are approximately 75 000 acres of irrigable land under this project in Arizona, and 15 000 in California. Of this area, 98% is subject to the provisions of the Reclamation Act, the owners of private lands having signed the necessary agreements to limit their holdings to the size of the farm unit to be determined, and otherwise to conform to the regulations required by the Service. A Water Users' Association, consisting of the land owners of the project, handles the affairs of the district, from the farmers' point of view, and has contracted with the Secretary of the Interior to accept and use the water under the usual conditions fixed in such cases by the Government.

The Imperial Valley should logically have been included as a part of this project, particularly from an engineering point of view. However, water had been delivered into the Imperial Valley for almost 3 years when the Secretary of the Interior approved of the Yuma Project. In addition, there were complications—largely over-estimated and far more apparent than real—due to the fact that it is practically imperative to go through Mexican territory with canals to serve the American Imperial Valley. The project, therefore, was limited, for the present at least, to the irrigation of the Yuma Valley.

Fig. 5 is a map of the restricted Yuma Project. As it occupies a position on the river above that of the California Development Company's constructions, and for that reason in many ways has had a very important influence on the whole irrigation of the Colorado delta proper and related engineering problems, its essential features will be briefly described first. These are a diversion weir, and the levee, canal, and drainage systems. The diversion is by an overflow weir of the type developed by British engineers in their irrigation work in India, and improved and used later on the Nile. It is of loose rock, rests on a bed of river silt, is almost a mile long, very wide, quite low, and is in general an exceptionally interesting and expensive construction.

The next most unusual and interesting feature is the necessity for about 74 miles of levees to protect, from the overflow waters of the river, the greater part of the land to be irrigated. The canal system, with the exception of the siphon under the Colorado, is nothing out of the ordinary, and the same is true of the drainage system.

The project has proved very much more expensive than was originally contemplated, the estimated cost being \$3 000 000, whereas, the construction expenditures up to June 30th, 1910, were \$3 617 472.71,* exclusive of maintenance and operation charges and \$100 000 of the preliminary survey costs more properly chargeable to general investigations along the Colorado River than to the Yuma Project itself. Work on the project was reported as 80.8% complete, but this estimate was revised in April, 1911, and changed from 81.6 to 52.4%, making the proper percentage completed on June 30th, 1910, about 51.8. On this basis, the total cost will be \$6 964 233, or approximately \$77.25 per acre of irrigable land.

Laguna Weir.—The location and general design of this noted structure were determined by the character of the bluffs on each side of the last narrow point of the Colorado Valley, where they were almost a mile apart, and the fact that borings disclosed no bed-rock at reasonable depths in the river bed. Accordingly, it was decided to build a low, wide diversion weir of the so-called "Indian" type. The original design, as shown by Plate CIII, was constructed with practically only one modification, namely, the interchange of the principal diversion from the Arizona to the California side.

Purpose.—The purpose of this structure, primarily, was to provide for silting out the heavier particles carried by the river, during flood periods especially, where such deposits could be sluiced out from time to time and in such a way that river floods would certainly carry them down stream.

Consideration will be given later to the silt problem, but it may be said that the only way of keeping the large, heavy, valueless particles of silt from getting into the distribution system, and clogging it, is to provide a settling basin where the water for a short time will either be practically still or the velocity reduced to not more than 0.5 ft. per sec., with freedom from eddy currents. Such deposits may be removed either by sluicing out with large volumes of water at a high velocity, or by using pumps, dredges, or some other kind of machinery. It was estimated that in the main canal, originally de-

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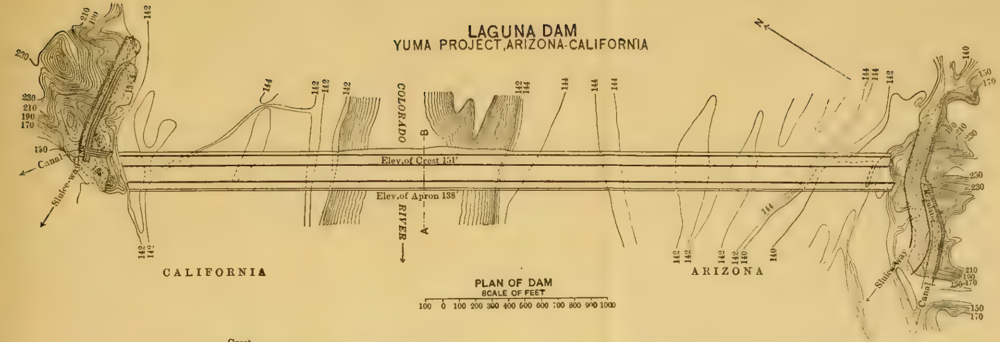
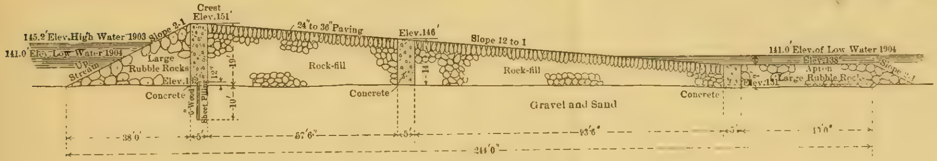
* Ninth Annual Report, U. S. Reclamation Service, Washington, 1911, p. 81.

PLATE CIII.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.

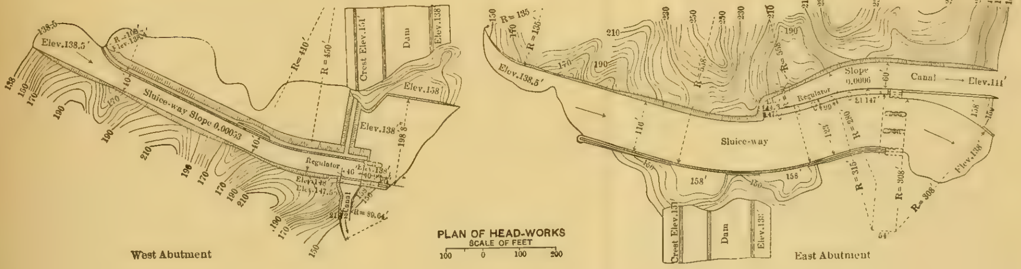
LAGUNA DAM
YUMA PROJECT, ARIZONA-CALIFORNIA



PLAN OF DAM
SCALE OF FEET



MAXIMUM SECTION ON A-B
SCALE OF FEET
10 0 10 20 30 40



West Abutment

East Abutment

PLAN OF HEAD-WORKS
SCALE OF FEET

signed to carry 1 600 sec-ft., the volume of wet silt to be removed therefrom daily was approximately 17 000 cu. yd. The sluice-way method of doing this means a higher initial cost and certainty of success, as compared with the very much lower cost, greater maintenance and operation charges, and somewhat less certainty of operation, for removal by machinery. The Laguna Dam (or rather weir) consists essentially of sluice-ways at each end of the structure, with a barrier between to hold up the water and afford a head for sluicing.

Sluice-ways.—The sluice-ways are controlled at their lower ends by large, vertical, steel-plate gates which are raised and lowered by electric machinery. The method of operation is to close the gates and cause the water in the sluice-ways above them to become practically still. The water thus held back quickly drops its heavier silt, while the canals are supplied through flash-board regulator gates in the outer sides of the sluice-ways, these gates being so long that a thin stream of water running over the tops suffices, and no water from near the bottom, where the sediment is greatest, is ever taken. From time to time, as may be necessary—and this varies greatly, depending on the stage of the river and the quantity of heavier silt particles carried—the gates are rapidly raised, and, with a fall of about 10 ft., the water rushes through the sluice-ways carrying away the silt deposits and dropping them a short distance below. During the annual and other floods, these deposits are taken up by the river and carried down stream. These sluice-ways are built through rock, their floor elevations being 13 ft. below the crest of the weir. They are lined and paved with concrete, and constitute a very massive and beautiful piece of work.

The Weir.—Between these sluice-ways the weir is built, the slope of the face being very flat, only 1 to 12, and capped with a concrete pavement, 18 in. thick, except a small portion which is paved with rough stones from 2 to 3 ft. thick. The crest was 10 ft. above the low-water mark at the dam when the structure was started,* and the top of the down-stream wall is 3 ft. below; thus the total fall of the face is 13 ft.

The weir was constructed simultaneously from each end, and a gap of 800 ft. was left in the center of the river channel. The original plan for completing this gap was by building upper and lower coffer-dams with piling, brush, and sand bags, but this was changed and finally the barrier rock fill dam, developed by the operations of closing the first and second breaks described later, was utilized. Before the central section was filled in, the sluice-way had been excavated and completed, the total capacity being more than enough to carry the low-water flow of the river. Rock was obtained in part from the excavation of the sluice-ways, and in part from the hills on each side; it was loaded on cars with derricks and steam shovels, and hauled by dinky locomotives to the various portions of the work. Coffer-dams made of quarry spoil were extended out into the stream, and inside these large pumps were used to clear of water. As much excavation as possible was done with teams and scrapers, and the remainder was taken out by suction dredges and pumps. Sheet-piling and the parallel concrete walls were then built, and the rock filling between was put in, followed up by the concrete surfacing. The actual quantities used exceeded the original estimates considerably; they are given in Table 6.

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* See discussion of variation in elevation of river bed at different times and different seasons, and the consequent low-water mark.

TABLE 6.

Rock excavation	444 640	cu. yd., or about	146% of estimates
Earth excavation	346 930	" " " "	123% " "
Rock in dam	375 018	" " " "	123% " "
Concrete*	76 066	" " " "	280% " "
Sheet-piling	82 779	lin. ft. " "	156% " "
Rock pavement	Insignificant—decrease.		100% " "

* In place of rock paving, the concrete surface was substituted.

On March 15th, 1905, bids for the construction of the Laguna Weir were opened, but those submitted were rejected and the work was re-advertised. Proposals were again opened on June 5th, and on July 6th, 1905, the contract was awarded at the following prices:

Rock excavation	$1.30	per cu. yd.
Earth excavation	0.30	" " "
Rock in dam	0.35	" " "
Concrete	4.00	" " "
Sheet-piling	0.40	" lin. ft.
Laying pavement	1.00	" sq. yd.

The contract required the work to be finished within 2 years, which would mean just at the time of the peak of the summer flood of 1907. These prices, on the estimated quantities, made the bid amount to

$797 650. There were seven other bidders, whose figures ranged up to $1 030 117.50. The Reclamation Service, under the specifications, supplied the cement to be used. On February 28th, 1906, the same firm was awarded the contract for furnishing and erecting the sluice-gates, regulator-gates, and operating machinery for the main sluice-ways and head-gates, the bid being $65 900. The contractors began work on July 19th, 1905, and a year later had completed 26.4% of the work.

As the quality of the rock obtained was much poorer than had been anticipated, the Board of Engineers of the Reclamation Service modified some requirements in the specifications and contract which resulted in increasing the contract price by $331 486, or to $1 129 136, and extended the specified time for completing the structure from July 19th, 1907, to January 19th, 1908. On January 23d, 1907, when about 34% had been completed, the work was taken over by the Reclamation Service direct. On July 1st, 1907, 52% of the work had been finished, a year later 77% was done; and it was practically completed in March, 1909, just before the summer flood of that year began.

The Reclamation Service gives the following costs* of the Laguna Dam and the sluice and regulator works:

Laguna Dam............................	$1 672 168.20
Sluice and regulator works................	345 295.92

Other recent operations along the river have shown that a structure serving every purpose of the Laguna Weir could have been built by methods now well known at far less cost. The building of rock fill dams in the bed of such a stream as the Lower Colorado was considered impracticable until the work of re-diverting the river developed such method. However, it is now evident that it would have been far simpler, quicker, and cheaper to have developed rock quarries, thrown trestles across the bed of the stream, and dumped rock therefrom to form a wide rock fill dam, without any concrete walls whatever, and covered the top with concrete. There would be no difficulty in beginning the construction of such a dam in the center of the stream and causing the river itself to excavate its bed opposite the rock fill as the latter should be built forward. In this way the excavation would have been made to a little greater depth than the bottom of the concrete walls actually put in. The rock for such a purpose would by preference be graded, so that quarry spoil would in no way be objectionable, and rock material obtainable in the adjoining hills could be blasted out in large quantities, loaded with steam shovels, and consequently obtained and handled very cheaply. A structure having essentially the same top dimensions and surface covering, and extending deeper into the river bed than the existing one, would in this way have cost far less and be even more secure from failure. There would be practically no seepage through or under such a dam or weir, as the similar constructions, very much thinner and sustaining much greater heads, which closed the first and second breaks, seem to be absolutely water-tight.

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* Ninth Annual Report, United States Reclamation Service, Washington, 1911, p. 82.

To the cost figures should be added the proportional share of the total administrative and general expenses. Such administration figures are given as $179 021.43, to which should properly be added at least $75 000 of the item: "Preliminary surveys previous to selection of project—$174 735.83," or a total of $254 021.43. These are probably the approximate general expenses to be distributed over expenditures totaling $3 717 472.71, or 6.89 per cent. On this basis, there should be added to the cost, for general expenses, $114 243.24, or a total for the Laguna Dam proper of $1 786 411.44, and to the sluice and regulator works $23 583.71, making their total $368 879.63, or a total of $2 155 291.07, not including the loss of $400 000 said to have been sustained by the contractor, which would raise the total to $2 555 291.07.

The result is a magnificent and permanent head-works for taking water from the Colorado to irrigate by gravity about 75 000 acres of land in the Yuma Valley; and, at some future time, this structure may serve as well for diverting water to irrigate the entire Colorado Delta. Its very great cost, however, raises the question as to whether the silt problem could not have been solved in a more economical and equally satisfactory manner by pumping depositions thereof, in an enlarged section of the canal, back into the river, with suction dredges. This question cannot be determined until the maintenance costs of the sluice-ways and diversion weir are shown by experience, and the total costs and results of handling the silt with dredges, as is now being done at the California Development Company's head-works, have been ascertained for a considerable period.

Levee System of the Yuma Project.—Practically all the valley lands in the Yuma Project are subject to overflow, so that a general and comprehensive system of levee protection is necessary. Fig. 5 shows this system, practically all of which has been completed. In general, the designs were for dikes 4 000 ft. apart along the Colorado and 3 200 ft. apart along the Gila, with a height of from 4 to 5 ft. above the high-water marks; as constructed, however, there are long stretches along the Colorado where the levees are only from 1 600 to 1 800 ft. apart.

The first levee construction was in accordance with the usual Mississippi River practice. The ground was cleared, stumps and roots were grubbed out, the base was plowed, and the levee was built with earth taken from borrow-pits on the river side. These borrow-pits were about 400 ft. long in the direction of the levee, with cleared traverses between about 12 ft. wide; 40-ft. berms; allowable depths of pits, 2½ ft. at the side nearest the levee and 3½ ft. at the farther side; levee top width, 8 ft; side slopes, 3 to 1 on the river side and 2½ to 1 on the land side. No muck-ditching was done.

The first stretch of levee constructed was 10 miles long, extending south from Yuma along the eastern bank of the river. In this section the current along the levee face was generally as little as would be expected anywhere on the project. Nevertheless, experience soon showed the desirability of an elaborate system of brush abatis work, a sample of what was put in here being shown by Fig. 1, Plate CIV. At many points where any considerable quantity of water had come against the face of the levee the borrow-pits had cut together, the traverses having quickly been cut through and the breach widened more or less seriously. As it was expected that the river would fill up these borrow-pits with silt in the first few floods, such a result was disappointing.

It seems that no trouble was caused by the absence of muck-ditch protection under the levee. This must have been due to the fact that the ground where the levee was located was uniformly favorable. In the fall of 1906, however, the levee system of the project was extended some miles southward along the river, and the flood which occurred on December 7th, 1906—which got under the newly constructed dikes on the west side of the river in many places and resulted in the second break or crevasse to the west—caused several breaks in this new section, due to the lack of muck-ditches in unfavorable ground.

Experience with the levees, including the effect of this last-mentioned flood on the levee system of the project and on the levee work done on the other side of the river, caused a fundamental change in the design. In January, 1907, a Consulting Board of Engineers from the U. S. Reclamation Service was appointed to consider the matter of levee construction being done with money advanced by the Harriman interests on the west side of the river, and its recommendations are given later. Up to that date, 21 miles of levees had been constructed on the Yuma Project, extending from Yuma southward 15 miles and eastward along the south bank of the Gila 6 miles. All construction thereafter has been in accordance with the recommendations of this Consulting Board for the levees of the west side of the river, the essential features of which are "interrupted or checker-board borrow-pits" on the water side of the dikes, muck-ditches wherever test-pits show the necessity, and a large quantity of brush abatis work.

In 1907, a railroad track was laid in large part on the levee, from the Laguna Weir to Yuma on the California side of the river, chiefly for the purpose of hauling materials and supplies to and from the Laguna Weir. The Southern Pacific Company owns and operates this track as a branch line, thus serving an area which will be under intensive cultivation very soon, and greatly facilitating levee maintenance and repairs. Over this track a very large quantity of quarry spoil was hauled from the Laguna Weir construction work and used to blanket the river side of this levee to a point below where the swiftest water along its face is to be expected. None of the other levees of the project has any blanketing or any track on top.

Canal System of the Yuma Project.—Fig. 5 shows the general layout of the canal system of the Yuma Project as it is planned at present and in considerable measure constructed. The principal main canal is on the California side, and has a capacity of 1 700 sec-ft. The main canal on the Arizona side will irrigate only the land north of the Gila River. Water for irrigating the land lying east and south of the Colorado and below the Gila is to be carried under the river at Yuma in an inverted siphon, 1 000 ft. long, 14 ft. in diameter, about 50 ft. below the bed of that stream, and having an estimated capacity of 1 400 sec-ft. This siphon is now under construction. The original plan was to serve this territory with water taken from the Arizona end of the dam and carried across the Gila River in four rein-

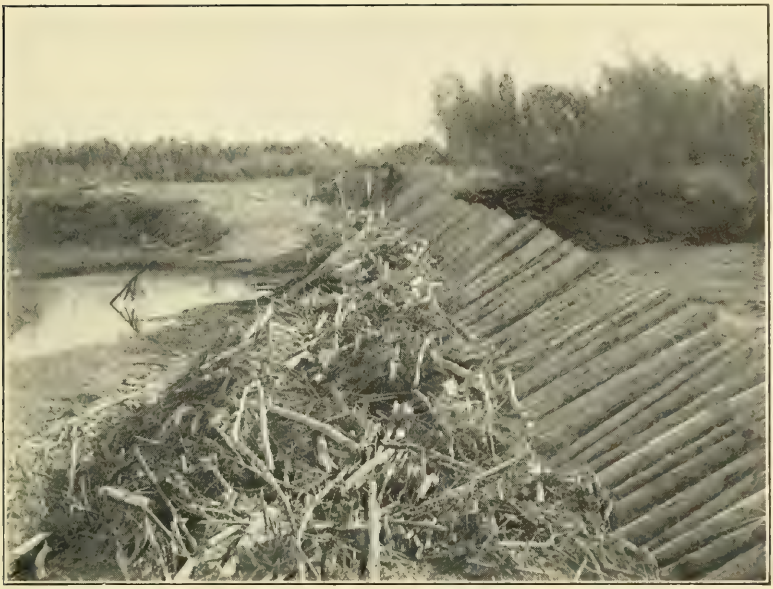

FIG. 1.—TYPICAL ABATIS WORK ON LEVEES OF YUMA PROJECT, U. S. RECLAMATION SERVICE.

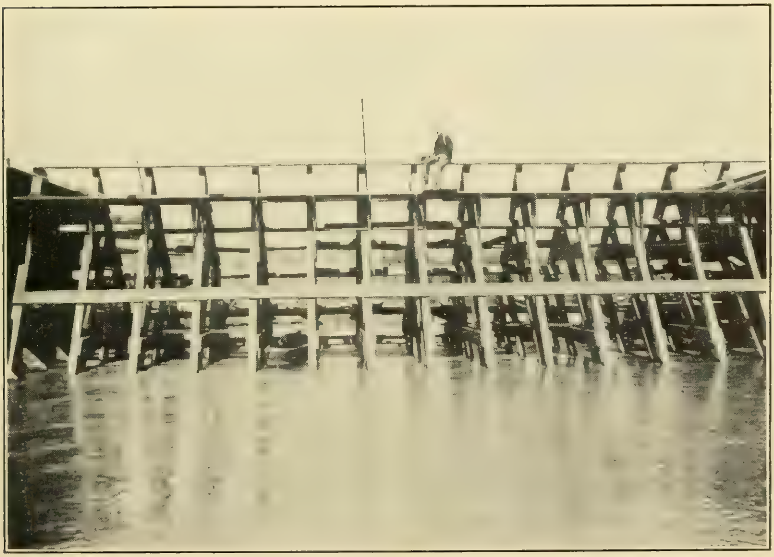

FIG. 2.—ORIGINAL INTAKE (CHAFFEY) GATE, IMPERIAL CANAL, COMPLETED IN 1901.

forced concrete tubes with a combined capacity of 1 300 sec-ft. and laid 3 ft. below the river bed. This crossing was abandoned because the difficulty of holding the Gila River banks at the ends of the underground siphon was considered too great. There is practically no danger of this kind in crossing the Colorado with the siphon, because of the little eminences of quite hard material which control the location of the river at this point.

The design of this siphon, the investigations of the material in which it is located, the first methods of construction used, the difficulties encountered, the changes in plans and methods, with the reasons therefor, the methods of doing the work finally adopted, and the time and cost figures, are all interesting in the extreme, but will not be given here for several reasons, chief of which is that, on the completion of the Yuma Project, it is hoped the work will be described at length in a paper by the Project Engineer, F. L. Sellew, M. Am. Soc. C. E., or some other engineer of the Reclamation Service. Only such general description is here given as seems desirable to make quite clear the effect of the project itself directly and indirectly on the irrigation of the delta.

The total acreage which will ultimately be irrigated by the Yuma Project is given in the reports of the Reclamation Service as 90 160. This includes 17 000 acres of mesa lands which lie too high to be reached by gravity from the principal canal system. It is intended to develop 1 000 h.p. at the drop in the main canal, and with this to operate pumps to raise water for the higher distribution systems.

At present the main canal from the Laguna Weir on the California side down to the California shaft of the river crossing at Yuma is under construction, and quite a little main and some lateral canals lying between these points and behind the line of the levees on the west side of the river have been completed and are in use. Such canal construction, and particularly the checks, head-gates, etc., are models of their kind, being of concrete and of the latest and most approved type. Up to the end of 1907, there were no canals on the California side of the river; indeed, practically all the area was contained in the Yuma Indian Reservation, which has since then in part been apportioned to individual Indians and in part, 6 500 acres, on March 1st, 1910, opened to entry and quickly taken up by white settlers. Two weeks later water was turned into the reservation canals, and rapid progress is being made in developing the region. On the east side of the river below Yuma about 8 000 acres are being irrigated through small canal systems which have been in operation for a long time and were taken over by the Reclamation Service since the creation of the project. The total acreage of the project to which water could have been supplied was about 16 000 acres, while about 10 000 acres were actually irrigated during the season of 1911.

Drainage System of the Yuma Project.—As has been said, a large acreage of the Yuma Project is subject to annual overflow, and lies behind the levees. The water-table throughout practically the entire region rises and falls with surprising rapidity during all floods which are long in passing. Thus it is that during May, June, July, and August particularly, the water-table rises so near the surface as to result in rather high alkalinity in the soil. The river water which will be applied for irrigation also carries a considerable, though not serious, quantity of soluble salts. Evaporation takes place from land surfaces very rapidly in such a hot country, and when water is on the surface, or approaches so near it that capillarity makes connection between the water-table and the surface of the ground, the quantity evaporated is excessive, and the salts contained are left behind, largely in the top layers. Therefore, efficient drainage is very important. It is made even more necessary because the rainfall is really inappreciable, having been less than 3 in. per annum for the past 15 years, and causes very little leaching and washing away of alkaline depositions. In passing, it is important to say that, very fortunately, the alkali of the valley lands is peculiarly a surface accumulation, often being confined to the very upper layers, usually to the first 2 ft. in depth, and seldom being found at depths exceeding 6 ft.

The Yuma Project, therefore, includes plans for an elaborate and efficient system of drainage canals which will be doing the maximum amount of work during the annual summer floods of the Colorado. It is planned, where necessary, to pump such drainage water over the levees and back into the river. This drainage system has not been constructed, and indeed the detailed plans may not yet have been worked out, but it is desired to state here that arrangements have been made for drainage in the Yuma Project, and results along that line must be obtained in the Imperial Valley sooner or later.

IMPERIAL VALLEY IRRIGATION PROJECT.

In 1893, Mr. Rockwood found himself in possession of much engineering and other information regarding the irrigation of the Colorado Desert with the water of the Colorado River, in lieu of salary for a considerable time as Chief Engineer of the Colorado River Irrigation Company, and had a firm conviction of the project's possibilities. For more than 7 years he endeavored to finance the work, both in the United States and abroad. Many people have suggested the irrigation of the Colorado Desert, as already mentioned, but Mr. Rockwood and associates actually brought it about. The very interesting history of the enterprise,* unfortunately, is accessible to relatively few people. In spite of his later mistakes, Mr. Rockwood is certainly entitled to much credit and reward for his efforts, which, practically speaking, were finally crowned with complete success.

Engineering Features.—The engineering features of irrigating the Imperial Valley from the Colorado River can now be much better understood than was possible in 1900. The experience of 10 years is always of value, and was particularly so in this case. The fall of the ground was known, and to divert the water and conduct it to the broad, ideally lying tracts of land to the west of the sand hills was obviously practicable. There were, however, two especially serious problems: the danger of diverting water from a wide, erratic stream flowing through a shifting channel along the top of a ridge of loose alluvial silt; and the difficulty of keeping open canals which carried water so heavily charged with silt.

Diversion.—The impossibility of properly financing the enterprise absolutely forced the abandonment of the idea of diversion at The Potholes, with its opportunities for settling basins and sluice-ways to care for the silt *en route,* and made the diversion at the rocky point of Pilot Knob practically unavoidable. It was always the idea to have a head-gate founded on solid rock. At the last, it was found impossible to obtain the money, even for this construction, but the diversion point was located there, with the intention of utilizing this rocky point of Pilot Knob for head-works, in the very near future, when the financial status of the company might permit.

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* "Born of the Desert," by C. R. Rockwood, in the Second Annual Magazine Edition, *Calexico Chronicle*, Calexico, Cal., May, 1909.

Flood Protection.—It does not seem to have been realized, at the time, or indeed by any one until the diversion into the Salton Sea was actually an accomplished fact in 1905, that there was any really appreciable danger to the Imperial Valley by flood-waters from the Colorado. The writer hopes especially, that the discussion will bring out any contradiction of this statement which may be successfully maintained. Of course, it was known that large quantities of water had been carried through the New and Alamo Rivers into the Salton Sea in 1891, and also by the New River earlier, especially in 1862, but the channels had not eroded to any marked degree at the gathering ground along the Colorado River bank, but, on the contrary, had automatically closed. Instrumental data regarding that portion of the delta cone which is subject to overflow were entirely lacking, and indeed, little other reliable information about the region was available. It was planned to build levees along the river side of the canal with the material taken from the latter, but the purpose of these levees was to protect the canal itself from danger, and not to keep the flood-waters which might enter this waterway from enlarging it to a dangerous degree. Of course, any risk of the river being diverted into the Salton Sink, and soon inundating the entire Imperial Valley, involves the same risk to the irrigation project as such. Otherwise, such risk should obviously not affect an irrigation company in any way, unless its operations and constructions have an appreciable effect on such river diversion.

Silt.—With this means of diversion it was necessary to let the silt-laden river water enter the canals directly, and depend on keeping them open by dredging, erosion, etc. The chief difficulty obviously must occur in the first stretches of the waterway, due to the rapid deposition of the heavier or sandy particles of silt which the river water carries during flood stages of excessively high currents, and which drops down almost at once when the velocity decreases to, say, 3½ ft. per sec. After such clarification, it is possible to design and operate canals in the Colorado Delta, as well as in India and elsewhere, so as to insure the carriage of the remaining finer silt into the smaller laterals and to the irrigated land. The first mile of the canal, therefore, was designed with a large cross-section so as to secure the deposition of this heavier silt there, where it could be removed by dredges.

Alkaline Lands.—From a farming point of view, a difficulty which was not given very serious consideration was the relatively high alkalinity in the upper layers of the soil throughout practically all the Imperial Valley. Wherever water came in contact with the ground, it was observed that vegetation at once sprang up like magic, and it was assumed, from this and from the obvious methods of its occurrence, that the soil must be exceedingly fertile and admirably adapted for general agricultural purposes. In one sense, a very serious mistake in this way was not made, for agriculture of almost unparalleled success has been followed for the past 10 years, with only at rare intervals a very slight thinning of crops indicating the need for proper drainage and the reduction of the excess of alkalinity.

In 1893 the Director of the Agricultural Experiment Station at the University of California was asked to investigate the agricultural possibilities of the land in the Imperial Valley. At that time it was proposed to provide an expedition properly equipped in order that the Director, Professor E. W. Hilgard, the great American authority on soils, might explore the region personally. The financial difficulties of the Company prevented carrying out the plan at the time, but a few samples of water from the lakes and of soil taken superficially, proved that the latter were very similar to that of the immediate bottom of the Colorado River, which previous analyses had shown to be of extraordinary intrinsic fertility.* In 1896 and 1897, some additional samples of soil and water were sent for examination. These corroborated the previous conclusions, but showed that a considerable quantity of alkali salts was present in the soils as well as in the waters, and thus indicated the desirability of a thorough examination of the region, from the soil standpoint. The subsequent soil investigations in the Imperial Valley and their effect on the fortunes of the region will be considered later.

Drainage.—While the country as a whole lies ideally for irrigation and ordinary irrigation water drainage, the natural waterways are so far apart and so small and ill defined as to make the construction of an efficient, comprehensive drainage system almost as difficult and expensive as the irrigation canal. In the engineer's report to the Colorado River Irrigation Company, it was stated that the construction of a drainage system (while almost as expensive as the proposed irrigation system) was essential, but some years later, when the work to be done was trimmed to the lowest practical minimum, it was decided that a general drainage system was not immediately necessary and possibly might never be required. This latter opinion was not as radical as might at first be assumed, because, even to-day, there are probably not more than 5 miles of drainage ditches in the valley. It is being realized in a general way that at some time provision for drainage must be begun, and within the next few decades doubtless a fairly comprehensive plan will be developed. The diversion of the Colorado into the Salton Sea in 1905-06 resulted in eroding the beds of the Alamo and New Rivers into deep wide channels which will be the controlling features in the design of the ultimate drainage system for the valley, and thus produce a benefit which in the end must certainly exceed the total damages resulting from such diversion.

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* Report, Agricultural Experiment Station, University of California, 1882.

Climate.—The climate of the region, with its long, hot, dry summers, is peculiarly favorable to agricultural luxuriance. Thus it is that here the very earliest grapes, fruits, and vegetables are produced for the United States market, with the consequent advantage of commanding the highest prices. This is notably true of the Imperial Valley cantaloupe, now famous all over this country, and of the early grapes, asparagus, etc. On account of the very low humidity and gentle winds which blow much of the time in hot weather, the sensible temperature—which is indicated by the wet-bulb readings and gives the measure of heat felt by the human body—is much less than the actual temperature as measured by the dry bulb. It is conservative to say that a temperature of 110° in Imperial Valley is not more uncomfortable than 95° in Los Angeles or 85° in the more humid sections of the Eastern States. Furthermore, the nights are always cool, the low humidity resulting in rapid and large daily temperature variations.

At the same time, the heat in the Colorado Desert and at Yuma was proverbial, and one of the difficulties which the project had to encounter was the supposedly frightfully hot summers; indeed, the project would otherwise have been financed very much earlier. Since the control of the diversion canal was lost in 1905, the impression has become general that the project of irrigating this region was rejected by capitalists as involving too great engineering risks. As a matter of fact, the chief difficulty was the fear that the torrid climate would render colonization very difficult.

The International Boundary Line at the Sand Hills.—Perhaps, everything considered, the location of the International Boundary Line and the Sand Hills which lie to the west of Pilot Knob and overlap into Mexico for several miles, constitute the most important features of the irrigation, and protection from inundation, of the Imperial Valley. It is this which makes it impossible for the people of American Imperial Valley to organize to protect themselves under the laws of California. The menace is entirely on Mexican territory, and, apart from the difficulty of dealing with the problem as one of engineering and statecraft, is the worst feature of all, namely, the seeming injustice of compelling American citizens to protect their homes against a menace originating entirely on foreign soil.

Aside from the danger of the diversion of the Colorado to the west and into the Salton Basin, the important result of the present location of the International Boundary Line is that, practically speaking, water cannot be taken from the Colorado River and carried in canals lying wholly on American soil to the areas in American Imperial Valley susceptible of irrigation by gravity. It could be done, but it would require approximately 12 miles of a closed conduit running under the sand hills and costing at least $10 000 000, a sum practically prohibitive.

Water Rights.—Due to the divided authority of the National and State Governments with respect to permission for taking water from the Colorado River as a navigable stream, water appropriation notices then, as now, had to be posted and filed, under the laws of the State of California, and arrangements had to be made with the United States War Department as well, if such diversion interfered with navigation. It appears that no attempt was made to obtain permission from the War Department for taking water from the river, because it was almost impossible to cause any "interference with navigation." This failure to secure permission from the War Department, however, had a very serious result later.

Ideal Plans.—The ideal way to carry such a project through is now quite obvious. All the engineering features should have been carefully worked out, elaborate soil surveys should have been made by well-recognized authorities, and experimental farms should have been established. The irrigation system should have been built in sections and colonized before additional areas were covered by canals. Water rights, entirely free from any possibility of attack, should have been obtained. In the light of experience, the writer believes that, by all means, these should have been obtained from the Mexican Government, and the diversion should have been made on Mexican soil, or the development should have been made under the Carey Act.

Dealings with Mexico would have meant the abandonment of the idea of diversion works founded on solid rock, but a structure with a wooden caisson foundation extending under the gates proper and the wing-walls would have been just as safe as the concrete head-gate actually put in later, and would have cost little more money, if indeed as much.

The ownership of all private interests in the Salton Sink ought to have been acquired, and such permission obtained from proper Government authorities that this naturally depressed basin would ever be available without question as a receptacle for the seepage, drainage, and waste water from the irrigated lands and canals. Data as to silt deposition and the cost of removing it from canals and intakes should have been obtained from experiments carried out on a commercial scale. Various details of the project, in short, should have been worked out very carefully and adhered to.

However, as in many irrigation and other projects in the West, the garment had to be cut according to the cloth. The sum total of events resulted in carrying out the project along lines which were far from ideal, but which later proved to be possible of execution with a remarkably small amount of money, everything considered.

The California Development Company.

The first practical step toward the actual irrigation of Imperial Valley was the incorporation of the California Development Company, under the laws of New Jersey, on April 26th, 1896. After two years of vain endeavor to obtain permission from the Mexican Government for the American corporation to hold land and acquire rights of way for the main canals into American Imperial Valley, it was found necessary to form also a Mexican corporation. The California Development Company has a capital stock of $1 250 000, divided into 12 500 shares of $100 each; the Mexican Company—*La Sociedad de Riego y Terrenos de la Baja California, Sociedad Anonima*—has a capital stock of $62 500, all of which is owned by the California Development Company. Hereafter in this paper the California Development Company will be referred to as the C. D. Co., and the subsidiary Mexican corporation as the Mexican Co.

The general practice throughout the West was, and still is, the sale of the "water right" to settlers at a definite price per acre—usually the right to buy water thereafter at specified prices. The arrangement adopted in this case was the formation of mutual water companies which would receive water wholesale and distribute it to their stockholders, the capital stock of such mutual companies constituting the water right.

Organization Under the Carey Act.—It would undoubtedly have been much better if the desert land in the United States had been segregated, and if the project, as far as American territory was concerned, had been carried out under the Carey Act. This Act, however, had not been passed when the original investigations were made, and, when financial arrangements were concluded, the California Legislature had adjourned and would not meet for nearly two years. Such delay was deemed too great.

Water Appropriations.—Water filings were made on April 25th, 1899, on the right bank of the Colorado River about 3 000 ft. above the International Boundary Line, by Mr. C. N. Perry, on behalf of the C. D. Co., appropriating 10 000 sec-ft., of the flow of the Colorado River to be used for the irrigation of American lands in the Imperial Valley. No serious attempt was made to obtain water rights in Mexico—in Mexican territory there was no chance to found diversion works on rock, and money for the first work of promotion would have been difficult to obtain with a projected intake in that country.

Rights of Way.—The C. D. Co. purchased 316 acres of patented land along the river just north of the International Boundary Line, and these included the rocky point of Pilot Knob; and the Mexican Co. acquired 10 000 acres in Mexico, belonging to Gen. Guillermo Andrade, and lying generally south of the Boundary Line, as shown in Fig. 7, together with the bed of the Alamo River, which extended beyond the boundaries of this tract. In the American Imperial Valley (all the land belonging to the Government) rights of way could not be purchased outright, but easements therefor were easily obtained as at present by application to the Secretary of the Interior, accompanied by maps and descriptions of the proposed constructions. All rights of way and property required for the construction of the project were thus arranged.

Contractual Relation of the C. D. Co. and the Mexican Co.—The two companies entered into a contract by the terms of which the C. D. Co. turned over to the Mexican Co. all the water to be diverted from the Colorado River by the former where the canal crosses the International Boundary Line at Algodones; the Mexican Co. agreed to deliver water to water users in Mexican territory as required and the remainder of the supply—the larger part by far—to the American water users at points on the International Boundary Line from 40 to 50 miles west of the river, and, from the water users of both countries, to collect for the water furnished, on a quantity basis; the C. D. Co. agreed to build, maintain, and operate all the Mexican Co.'s irrigation construction in Mexico; the Mexican Co., in consideration thereof, agreed to pay the C. D. Co. all sums received by the former for water rights, water stock, and water rentals from water users in the United States. These agreements were limited to water for lands which were irrigable by gravity from the system of canals beginning at the head-works constructed. It was stipulated, further, that no contract should be entered into with the Mexican Co. giving any person or corporation superior right over any other water user by reason of priority in date of contract or otherwise, and that the C. D. Co. should not be responsible for failure to deliver water to the Mexican Co. from any cause beyond its control, although admitting obligation to use due diligence in protecting canals and maintaining the flow of water therein.

By this arrangement, the Mexican Co. retains the money received from the water delivered to Mexican water users, and is put to no construction, maintenance, or operation expense whatever. This arrangement, however, is not as advantageous as at first appears, because the gross annual water rentals from Mexican water users did not amount to $10 000 gold per annum until the beginning of the ninth year, while the right of way contains at least 2 500 acres of land and includes 50 miles of the Alamo River channel, which is utilized as a main canal. It will be a number of years yet before the receipts of the Mexican Co. will be sufficiently large to make the contract an unusually profitable one.

Mutual Water Companies.—Next to the general plan of arranging to require the purchase by settlers of the water right usual in such cases, the fundamental idea was delivery of water to mutual water companies instead of individuals, the mutual companies to be operated by the holders of stock, namely, the farmers in their respective districts. The various mutual companies thus run their own local affairs and join together, through the C. D. Co. and the Mexican Co., in a community main canal leading from the river to the settlement west of the Sand Hills.

Triparty Contracts.—The mutual water companies required the construction of a distribution system, and ought or ought not to have paid a bonus for the contract to receive water at the International Boundary Line, depending entirely on the conditions under which the water should be delivered and the price to be paid for it. A triparty contract was entered into between the Mexican Co., the C. D. Co., and each of the mutual water companies, under the terms of which the Mexican Co. agreed to supply water to the mutual water companies "on demand" and at definite points on the International Boundary Line in the Imperial Valley for 50 cents per acre-ft., to be used only on lands within the respective districts; provided, however, that the aggregate quantity of water necessary to deliver under the contract should not exceed four times the number of acre-feet per annum that there were shares of capital stock in the mutual company; the mutual company agreed to order and pay for at least 1 acre-ft. of water each year for each share of its stock sold and located, regardless of its use by the mutual company or by its stockholders; the C. D. Co. agreed to build the distribution system of the mutual company and to maintain certain definite portions of the canal thereof perpetually, reserving the right to develop and use the water-power that might be obtained from the waters running through any of the canals, including those of the mutual company; a provision was made that at the end of 3 years the loss of water to the C. D. Co. in evaporation from the canals of the mutual company should be determined, and such an extra allowance of water be supplied, as so determined, to the end that only the net quantity reaching each half section of land should be paid for; and the mutual water company turned over all its capital stock to the C. D. Co. and agreed to locate such stock on any lands within the exterior boundary lines of its district on order of the C. D. Co. The C. D. Co. sold the capital stock of these various mutual companies to the settlers, and with the proceeds built the main canals in the United States, the canal system in Mexico which belongs to the Mexican Co., and the distribution systems which became the properties of the various mutual water companies.

There were eight of these triparty contracts; they were essentially similar, though no two were exactly alike in every detail. The contract between the Mexican Co. and the C. D. Co., and the triparty contract as just outlined, together with the by-laws of the mutual companies, show the contractual relation of the water user to the organizations on which he depends for water. These by-laws, in general, provide that each share of stock shall represent the right to purchase water for the irrigation of 1 acre of land; that stock issued shall have written on its face a description of the land on which it is located; that no stock shall be located on any lands outside those described in the articles of incorporation; that one share and no more shall be located on each acre of land which can be served by the ditches of the company; that owners of stock issued but not located shall not be entitled to receive any water represented thereby, but shall, nevertheless, be liable for all assessments, the same as other outstanding stock of the company; that the shares may be transferred; and that acceptance by any stockholder of a certificate of stock shall be considered as a ratification by him of any and all contracts between the mutual company in question and the C. D. Co.

The inter-relations of the water users and the various corporations have been given in detail because of a general impression that the plan was devised for the purpose of taking advantage of the settlers. In its operations it has resulted in no unfairness of any importance to any of the parties concerned. Considering all the circumstances, the prices charged for water rights were very low—$8.75 at the beginning, up to $20 at present, and averaging $12 per acre as the total cost to the settler, on easy terms—and the total annual water rental from the water users in the valley will not suffice to pay maintenance, operation, and general expenses, properly figured, until such time as about 700 000 acre-ft. of water are sold annually. At the end of 9 years the sales have not yet reached that figure. Fig. 4 shows the boundaries of the lands of the various mutual water companies in the valley and under whose distribution systems lie all the lands which are as yet irrigated.

TABLE 7.—Comparative Statement of Earnings and Expenses of the California Development Company, for November, 1909.

(Property on a seriously deteriorating basis.)

	November, 1909.	5 months, ending November 30th, 1909.
Earnings:		
Water sales	$13 906.20	$93 236.75
Water-power royalties	418.90	1 772.80
Rent, buildings and other property	82.05	488.51
Miscellaneous earnings	66.45	420.68
Gross earnings from operation	$14 473.60	$95 918.74
Operating Expenses:		
Maintenance, canals and structures:		
Superintendence	$163.83	$641.63
Maintenance and cleaning canals	10 588.76	47 130.74
Bridges	223.04	408.88
Canal structures	901.70	2 444.57
Buildings, fixtures and grounds	824.81	3 192.44
Total	$12 702.14	$53 818.26
Maintenance of levees:		
Superintendence	....	$210.00
Patroling	$102.55	377.87
Roadway and track	126.12	1 034.01
Telephone and telegraph lines	84.87	217.04
Buildings, fixtures and grounds	....	44.37
Total	$313.54	$1 883.29
Maintenance of equipment:		
Vehicles	$85.23	$576.47
Grading implements	....	14.23
Corrals	29.01	525.56
Machinery	....	533.45
Shops	34.71	155.25
Automobile	135.36	1 115.04
Motor cars	83.34	154.46
Dredges	281.42	938.18
Total	$649.07	$4 012.64
Distribution of water:		
Superintendence	$163.70	$997.22
Zanjeros	760.00	3 858.63
Calibration and water measurement	21.52	365.00
Telephone and telegraph lines	163.40	815.53
Damages	....	50.00
Total	$1 108.62	$6 086.38
General expense:		
Salaries and expenses, general offices	$2 981.66	$15 444.09
Office expenses	332.37	1 515.04
Law expenses	618.28	3 899.92
Stationery and printing	132.36	684.86
Other expenses	107.40	459.67
Total	$4 172.07	$22 003.58
Total operating expenses	$18 945.44	$87 804.15
Net earnings	*$4 471.84*	$8 114.59
Taxes	$197.76	$1 134.88

Operation of Triparty Contract.—For 3½ years the writer was General Manager for both the C. D. Co. and the Mexican Co., and handled all matters between these companies and the various mutual water companies. During the latter portion of that time, the protection of the Imperial Valley from inundation by the Colorado had become quite as important as its irrigation, and, for this protection, of course, no provision was contemplated in these contracts. Except for that, the arrangement proved to be very satisfactory, and produced a smooth and comfortable relationship unusual in irrigation enterprises. As a result of litigation, however, the Supreme Court of California has just declared the whole scheme practically illegal, the text of the decision not yet being available. The Imperial Irrigation District was created several months ago, and the directors thereof have decided to take over only the functions which the C. D. Co. and the Mexican Co. now perform, and will not interfere in any way with the mutual water company plan of organization, or the water companies themselves.

TABLE 8.—STATEMENT OF EARNINGS AND EXPENSES OF LA SOCIEDAD DE IRRIGACION Y TERRENOS DE LA BAJA CALIFORNIA.

	November 5th, 1909.	5 months, ending November 30th, 1909.
GROSS EARNINGS	$641.20	$5 127.39
OPERATING EXPENSES:		
Distribution of water	0.00	0.00
General expense:		
Salaries and expenses, general officers and clerks	421.54	2 073.85
Office expenses	64.07	341.32
Law expenses	223.99	696.64
Stationery and printing	39.55	101.21
Inspection fund (Mexican Government)	150.00	750.00
Other expenses	231.25	663.47
Total	$1 130.40	$4 626.49
Total operating expenses	$1 130.40	$4 626.49
Net earnings	*$489.20*	$500.90

Imperial Land Company.—The parties who were induced to back the enterprise financially were afraid of the colonization end, and would have nothing whatever to do with it. Accordingly, it was necessary to form a colonization company—the Imperial Land Company—which was incorporated under the laws of California in March, 1900, and consisted in part of some of the promoters of the C. D. Co. and in part of other people. This corporation contracted to do all advertising and colonizing and sell all water stock in consideration of having the exclusive privilege of town sites and a commission of 25% on water stock sales. By using Government land scrip, this company obtained immediate ownership in fee simple of tracts of land in various parts of the valley and subdivided them into town sites. These town sites were covered with water stock in order to obtain water for domestic and municipal use through the assistance of the mutual companies, because no wells, except some very deep and unsatisfactory ones quite recently sunk on the east side of Imperial Valley, have ever been possible for domestic supply. The Imperial Land Company thus established the town sites of Mexicali, in Mexico, and Calexico, Heber, Imperial, and Brawley, in California. The other town sites—El Centro, the county seat, Holtville, Seeley, Dixieland, and several smaller places were platted and put on the market by other parties.

TABLE 9.—OPERATING EXPENSES OF CALIFORNIA DEVELOPMENT CO., JANUARY 1ST, 1908, TO MARCH 31ST, 1909.

	1908, 12 months.	1909, January, February, and March.
Maintenance, canals and structures	$71 419.94	$18 177.32
Maintenance, levee	10 260.35	647.24
Maintenance, equipment	18 528.69	4 182.21
Distribution of water	15 613.42	4 559.10
General expense*	75 162.82	12 277.76
Construction of canals	73 765.12	27 359.47
Construction of levees	32 303.09	32 297.84
Totals	$297 053.43	$99 500.94

* Of this sum, $30 665.28 was litigation expenses and costs.

During 1911 the total net deliveries of water to the mutual water companies in the United States were 597 178 acre-ft., or $298 490.98.

This colonization company in general was successful, but not to the extent which would be expected, considering the unprecedentedly rapid settlement of the region, and the contract was certainly a fair one to the C. D. Co., up to the time of its abrogation in 1906. Water stock was sold to the settlers for small cash payments and notes payable in five yearly settlements at 6% interest, such notes being secured by a mortgage on the water stock purchased. Many of the settlers had scant means and only a filing right on the land, so that the water stock was not made appurtenant to the land, but left as personal property. The initial payment went to the Imperial Land Company, and was by it used for advertising and other essential purposes, the collateral notes and mortgages secured by the water stock being taken by the C. D. Co.

TABLE 10.—AVERAGE DIVERSION AND DELIVERIES OF WATER BY THE CANAL SYSTEMS OF THE C. D. CO. AND THE MEXICAN CO. FOR THE WEEK ENDING JANUARY 19TH, 1912.

Gauge at Yuma		15.3 ft.
Gauge opposite intake		105.9 “
Elevation of bottom of diversion gate		98.0 “
Average flow of Colorado River at Yuma		4 000 sec-ft.
Diversion from Colorado River at Andrade		1 559 “ “
Used in Mexico	37 sec-ft.	
Used in United States	894.6 “ “	
*Wasted at Rositas waste-gate	321.3 “ “	
Total		1 252.9 sec-ft.
Total loss, Andrade to Sharps		306.1 sec-ft.

* 171.1 sec-ft. of this passed through the plant of the Holton Power Company *en route* to this waste-gate for developing electrical energy.

This loss equals 19.6% in about 46 miles of main canal, chiefly the bed of the old Alamo River, or 0.43% per mile on the average—an extremely low figure.

Management of the C. D. Co.—Delta Investment Company.—Until the water rentals became of importance, these collateral notes and mortgages constituted the only receipts of the C. D. Co., and these assets were looked on with considerable suspicion by the financial institutions of Los Angeles. Nevertheless, they were taken as collateral at about 25 cents on the dollar until the merit of the entire enterprise was rendered questionable in various ways, as explained later. When this occurred the Delta Investment Company was formed—in the fall of 1901—with assets consisting solely of C. D. Co. and Imperial Land Company stock contributed by the wealthier people of the enterprise, whose confidence was waning. This company was given a contract to take over all the C. D. Co.'s bonds at 50 cents on the dollar; and all its collateral notes and mortgages at the same discount. By this arrangement, the Delta Investment Company faction absolutely controlled the C. D. Co., although the amount of the C. D. Co. stock held by it was much less than a majority.

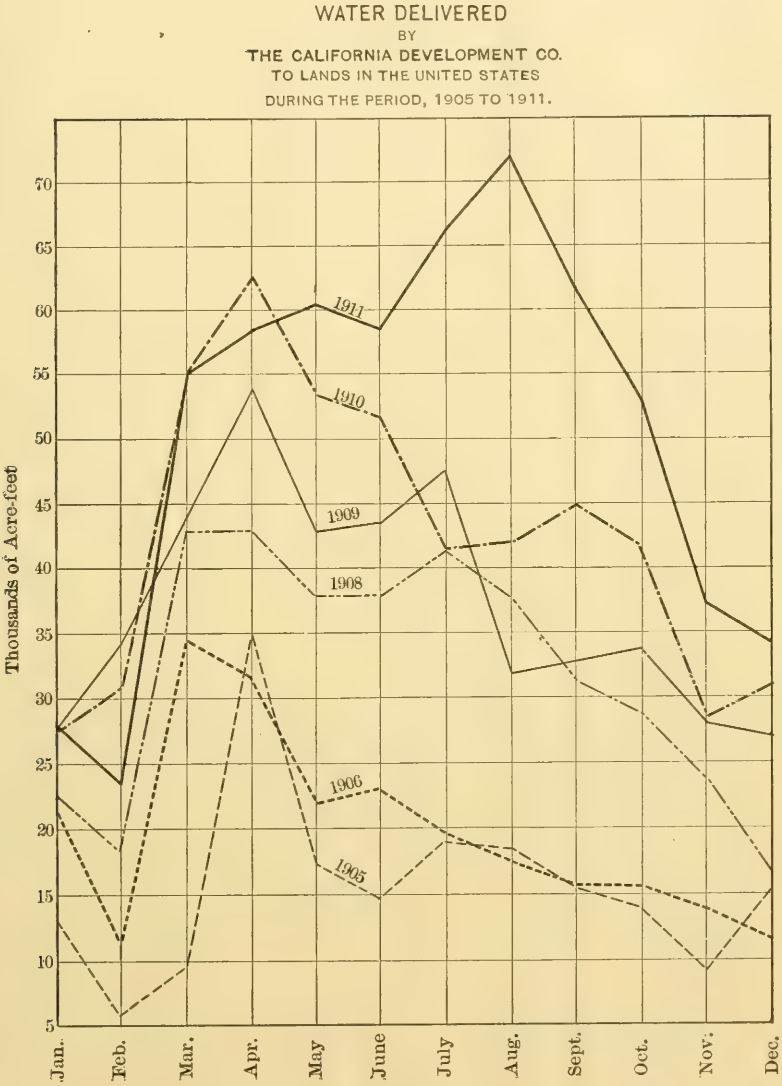
WATER DELIVERED
BY
THE CALIFORNIA DEVELOPMENT CO.
TO LANDS IN THE UNITED STATES
DURING THE PERIOD, 1905 TO 1911.
Thousands of Acre-feet
70
65
60
55
50
45
40
35
30
25
20
15
10
5
1911
1910
1909
1908
1906
1905
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

FIG. 8.

TABLE 11.—Annual Expenditures of Imperial Water Company No. 1 for 1911.

Capital stock = 100 000 shares, all of which have been sold, and are located on 100 000 acres of land. Total length of canals = 373.25 miles.

Maintenance:		
Superintendence	$7 000.00	
Engineering	1 600.00	
Corral	3 805.11	
Automobile	500.00	
Shops	2 463.13	
Materials and supplies	22 046.11	
Labor, men and teams	75 887.41	
Damages	645.91	
Muskrats, bounty at $1 each	492.00	
		$114 439.67
Operation:		
Superintendence	$3 815.74	
Engineering	168.81	
Zanjeros	22 609.02	
Corral	3 192.36	
Automobile	476.39	
Materials and supplies	1 892.98	
Telephone	260.16	
Water meters	260.47	
		32 675.93
General Expense:		
Salaries	$6 410.02	
General expenses	2 971.13	
Printing and stationery	439.94	
Taxes and insurance	956.59	
Furniture and fixtures	520.45	
Legal expenses	10 889.38	
		22 187.51
Imperial Water Company No. 1, expense		$169 303.11
Water Bought (from the C. D. Co.) 305 183 acre-ft., less 10% allowance for seepage and evaporation, at 50 cents per acre-ft., on net amounts		137 332.50
*Total expenditures**		$306 635.61

* The expenses of the company were almost exactly $1.70 per acre, and the water rentals paid to the C. D. Co. $1.37 per acre. The total cost to the farmers, therefore, averaged $3.05 divided by 2.747, or $1.11 per acre-ft.—a very low figure for water in California, where the "water right" averages $12 per acre, or indeed much more.

It must be admitted that the Delta Investment Company took over such securities at a larger price than could have been obtained from any other source. Nevertheless, the securities were really good, everything considered, and quite a few large and apparently strange and dishonest transactions were made between the two corporations resulting to the great benefit of one faction of the C. D. Co. at the expense of the other. Money was forthcoming for construction purposes, but was costing the C. D. Co. $2 for every $1 obtained. The result was that in a couple of months serious dissensions arose, and in February, 1902, an adjustment was made cancelling the contract with the Delta Investment Company and eliminating the original financial backers from further connection with the enterprise. March 1st, 1902, therefore, found the C. D. Co. with all its bonds gone, its collateral notes and mortgages largely depleted, no money in the treasury, and deeply in debt. Shortly afterward actual results from farming under the project were so reassuring that the company was able to borrow $25 000 from the First National Bank of Los Angeles and begin afresh.

The contract with the Delta Investment Company was a serious thing for the C. D. Co., but, to be perfectly fair in presentation, it must be borne in mind that the financial interests backing the enterprise had their confidence in the project so violently shaken by advance rumors of an adverse Government soil report (to be discussed later) that they felt justified in trying to get back all that might be possible from the wreckage.

With the exception of the arrangement with the Delta Investment Company, no proper criticism can be made of the handling of the finances of the whole irrigation project, as far as any of the promoters of the irrigation company are concerned. The writer has had opportunity and occasion to investigate thoroughly the relationship of all the corporations, and in common fairness must state that, while the deals back and forth were many and diverse, they were otherwise with very few exceptions reasonable and fair, when the circumstances and reasons which produced them are given the proper weight. Furthermore, the general aims and plans which the company practically succeeded in carrying out do not merit any more criticism than those of the average Western irrigation project, if indeed as much. Had the break in the Colorado River never been allowed to get beyond control—and it never would have happened, in spite of all obstacles, had the loan of the Southern Pacific Company (referred to later) been arranged 6 months earlier than it was—the C. D. Co. would undoubtedly have proved to be one of the most successful private irrigation enterprises throughout the entire land.

Colorado River Land Company.—It is well at this time to mention the Colorado River Land Company and the New Liverpool Salt Company. The former is a corporation consisting principally of Southern California stockholders, incorporated under the laws of Mexico, and owning about 1 000 000 acres south of the International Boundary Line and west of the Colorado River. It owns all the Colorado River Delta west of the river in Mexico except 162 000 acres, the location of these holdings and those of other important Mexican land owners being shown on Fig. 4. The existence and operation of this corporation have lately become important as being the agency through which the United States Government has handled the river control work recently done by it. The company will hereafter be referred to as the C. M. Co., as it is locally called.

The New Liverpool Salt Company.—This corporation was organized many years ago for the purpose of obtaining salt from the deposits in the bottom of the Salton Sink, and began operations in 1884. In 1904 its plant was reasonably satisfactory in its details and had a capacity of 1 200 tons of salt per month. The actual value of the plant and the salt beds, taking into consideration the excellent quality of the salt,* the conditions under which the Company operated, and the competition it had to meet, is of course impossible to determine without access to the company's records. It appears, however, that negotiations at that time were pending for its sale, the figures being $150 000 asked and $100 000 offered. When the water began to come into the sink in large quantities, negotiations were dropped, and the entire plant was soon buried by the Salton Sea.

Operations of the California Development Company.

When the C. D. Co. was ready to begin operations, there was on the lower river a dipper dredge with a 4-yd. bucket which had been built and equipped by Hon. Eugene S. Ives, of Yuma, Ariz., and his associates, for digging irrigating canals near Yuma. This dredge was bought by the company in exchange for guaranteed bonds, floated down the river, and, in August, 1900, set to work excavating a canal along the lines marked "Original Intake" in Fig. 9 and then following the old Alamo overflow channel to a point 8 miles below. From that point the Alamo channel, with a little diking here and there, had sufficient capacity to carry for some time the water needed.

About 500 ft. above the Boundary Line a temporary wooden headgate, Fig. 2, Plate CIV, known locally as the "Chaffey" gate, was put

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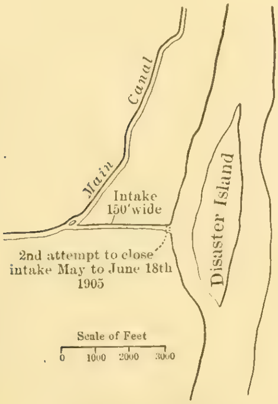
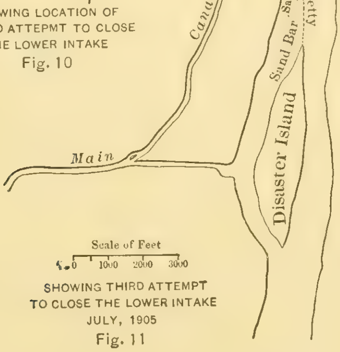
* The published analyses of the deposit give the following average:

Sodium chloride	96.15
Sodium sulphate	0.70
Calcium sulphate	0.60
Magnesium sulphate	1.60
Insoluble	0.10
Water	0.85
	100.00

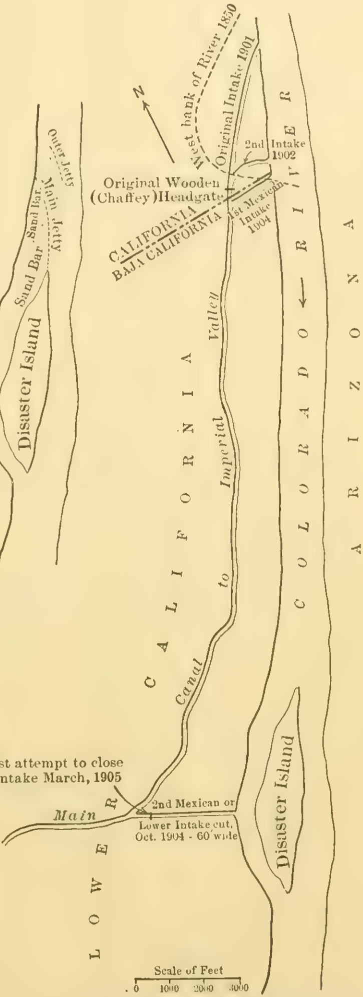
The California State Mineralogist reports the value as $1 per ton.



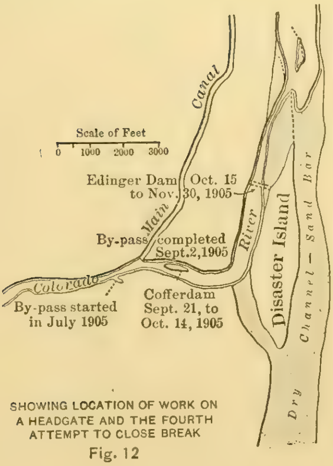
SHOWING LOCATION OF SECOND ATTEPMT TO CLOSE THE LOWER INTAKE
Fig. 10



SHOWING THIRD ATTEMPT TO CLOSE THE LOWER INTAKE JULY, 1905
Fig. 11



MAP SHOWING VARIOUS INTAKES OF THE CANAL TO IMPERIAL VALLEY AND LOCATION OF THE FIRST ATTEMPT TO CLOSE THE LOWER ONE
Fig. 9


Scale of Feet
0 1000 2000 3000
Main Canal
Edinger Dam Oct. 15 to Nov. 30, 1905
By-pass completed Sept. 2, 1905
River
Disaster Island
Colorado
By-pass started in July 1905
Cofferdam Sept. 21, to Oct. 14, 1905
Dry Channel — Sand Bar

SHOWING LOCATION OF WORK ON A HEADGATE AND THE FOURTH ATTEMPT TO CLOSE BREAK
Fig. 12

in. This was a well-designed and well-built wooden, **A**-frame, flash-board gate, 70 ft. long, 15 ft. high, with a plank floor, and founded on piling. When it was built* nothing was known or even suspected with reference to the rapid and large variation in elevation of the river bed at varying flood stages and otherwise, and it is not surprising, therefore, that the floor was not put as low as it should have been, but, even so, it was not as deep by 5 ft. as planned by Mr. Rockwood, who, by the way, from April, 1900, to February, 1902, was not in charge of the engineering side of the enterprise, Messrs. George and Andrew Chaffey, now of Los Angeles, handling the property. The structure was made no larger, not because of cost, but because it seemed certain that when more water than the gate's capacity should be required, that fact would mean such revenues as to permit building the permanent concrete and steel diversion works at Pilot Knob, regardless of all other considerations. In passing, it may be said that the construction and design of this temporary head-gate was fully equal to that of any throughout the West, even to-day. The floor, however, was quite too high.

At what is known as Sharp's Heading, the Alamo channel was abandoned as the main canal, and the controlling works for the valley end were put in. These consisted of a wooden, **A**-frame, flash-board gate in the continuation of the Alamo, a similar gate at the head of the Encina or West Side Main canal, and a combined gate and drop, known as Sharp's Head-gate, from which leads off the Central Main, the chief canal in the valley.

This last structure is well worth describing in some detail. In the first place, it is a most vital part of the system, because, being a combination of a drop and regulating gate, were it to fail, the water in the Alamo or Main Canal above it would immediately be lowered far too much to permit taking out any whatever for the East and West Side Mains. To realize the consequences of this, it must be remembered that irrigation water is needed every day in the year, and that no stock and domestic water for the entire region, except for the Town of Holtville, can be had, except from the irrigation system and by being brought in by the railroad in water cars. In the second place, for several months consecutively, in each year since 1905, it has

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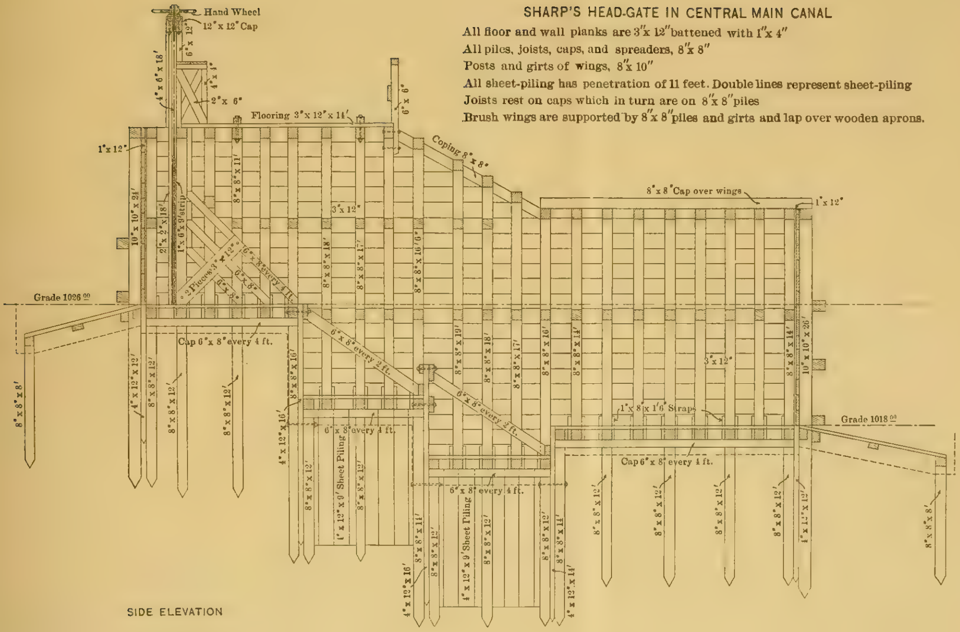
* Nothing really was known about the changes in elevation of the river bed until 1907.

SHARP'S HEAD-GATE IN CENTRAL MAIN CANAL

All floor and wall planks are 3″ x 12″ battened with 1″ x 4″
All piles, joists, caps, and spreaders, 8″ x 8″
Posts and girts of wings, 8″ x 10″
All sheet-piling has penetration of 11 feet. Double lines represent sheet-piling
Joists rest on caps which in turn are on 8″ x 8″ piles
Brush wings are supported by 8″ x 8″ piles and girts and lap over wooden aprons.



SIDE ELEVATION

been taxed beyond the capacity for which it was designed, without developing any serious weakness. Furthermore, at intervals of about 18 months, since it was put in service in 1903, the canal above it has been emptied for periods of not more than 60 hours to permit of inspection and light repairs, but the very first overhauling or extensive repairs were begun on January 5th, 1912.

The writer confesses to a predilection for permanent structures of masonry, concrete, or steel, and this gate and the Alamo Waste-gate, built in 1905, were nightmares to him while in charge of the properties. It would seem that a large part of this was worry wasted, however.

Sharp's Head-gate was designed by, and built under the direction of, Mr. C. N. Perry, then Resident Engineer of both companies, the fundamental idea being to cut up the foundation into a number of water-tight compartments. Plates CV and CVI show this construction.

Where Beltran's Slough leaves the Alamo channel, a wooden, flashboard gate was built to waste water through Beltran's and Garza's Sloughs into the New River, but about 3 months after being put in service it failed, due to back currents below it.

The original plan for supplying the territory to the east of the Alamo was to utilize the Alamo channel from Sharp's Heading to Holtville, an earthen dam being used to bring the water to the surface of the land at that point. This dam soon failed, and the canal from there was connected with the Alamo at a point about 1½ miles above Sharp's, such connection being made in record time, with a cross-section only large enough for the demand. The idea was that erosion would enlarge it, which in general has been the case, although some blasting was required to assist the action. Originally known as No. 5 Main, the canal is generally called the East Side Main. It, as well as the West Side Main, is occasionally broken in places by the severe rainstorms—almost cloudbursts—which occur at infrequent intervals in the region. To provide absolute protection against such damage would be very expensive, and neither No. 5, which owns the exposed portion of the East Side Main, nor the C. D. Co., which owns all the West Side Main, has done so. Otherwise they, as well as the Central Main, are quite satisfactory.

Main canals were constructed from Sharp's to serve the territory between the New and Alamo Rivers (the Central Main); a second, the

West Side Main, crossed New River to serve territory west of that waterway, and a third, the East Side Main, to serve the territory east of the Alamo. In 11 months, or in June, 1909, delivery of water was begun through the Boundary Canal as far west as Calexico, and the Central Main was put into service in March, 1902, or in 19 months.

Imperial Water Companies Nos. 1, 4, 5, 6, 7, and 8 were formed, and triparty contracts were entered into with each. The C. D. Co. constructed the distributing systems for these districts, with the exception of that of Imperial Water Co. No. 7.* The total length of canals in all these distributing systems was approximately 700 miles on January 1st, 1905, and there were also about 80 miles of canal belonging to the C. D. Co. and the Mexican Co., making the total about 780 miles. During 1905 and 1906 relatively little canal building was done, because the river got beyond control; and, from 1907 to 1911, inclusive, the increase has been less than 20% on account of excessive litigation following the vast expenditures for controlling the river, and because the canals existing on January 1st, 1905, covered 85% of the territory now under ditches.

With the exception of a permanent diversion gate at the river, two permanent structures replacing temporary ones in the valley, the building of the Alamo Waste-gate (Fig. 1, Plate CXIV), just above Sharp's Heading (June 25th to August 17th, 1905), and another in the Central Main at Station 134 (November 13th, 1904, to January 12th, 1905), that portion of the canal system completed on January 1st, 1905, has not been essentially changed or enlarged, and, with few exceptions, the original structures are still being used. There is a marked tendency on the part of the mutual water companies to replace wooden structures with permanent ones of reinforced concrete, but otherwise in general the canal systems are as satisfactory as any which could be devised.

The irrigation service afforded to farmers in Imperial Valley is the best of which the writer has ever heard. This has been the case with the exception of three short periods: the winter of 1904, 1 month

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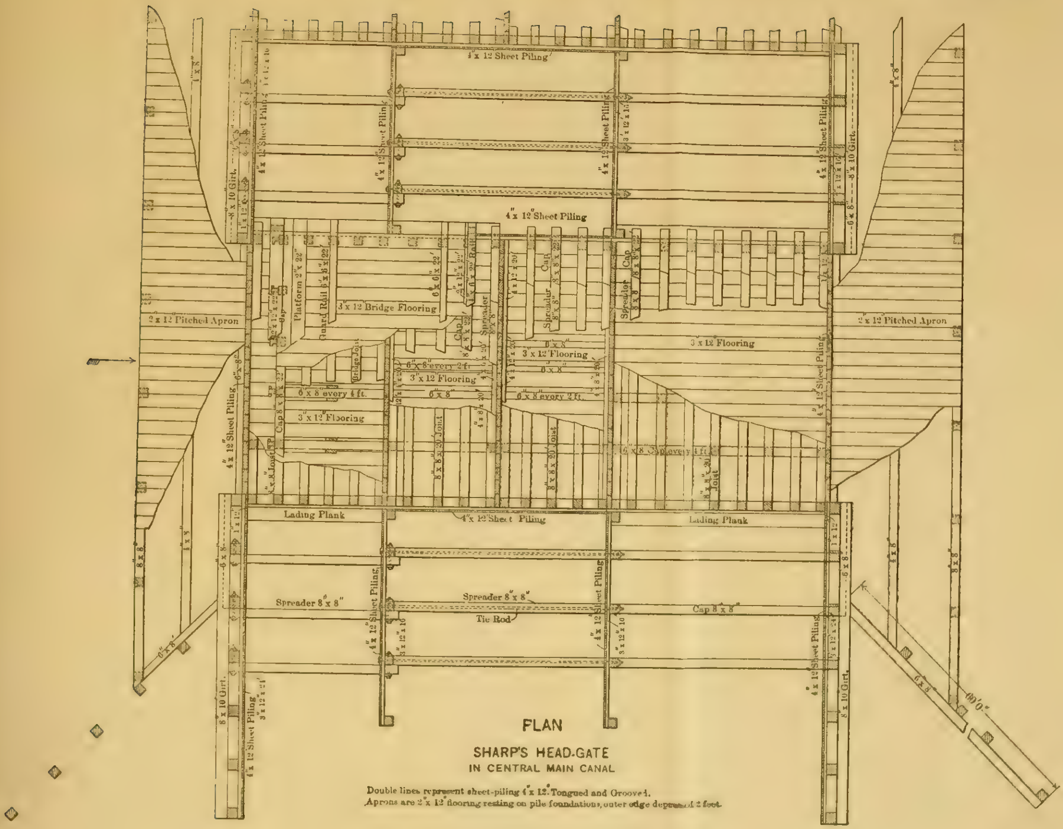
* The water rights for all the land south and east of the district of Imperial Water Co. No. 5 which could be irrigated by gravity from what was known as the Holt Heading—where the East Side Main heads—approximately 18 000 acres, were sold for $50 000, the purchaser, Mr. W. F. Holt, from Mutual Water Company No. 7, constructing the distribution system and selling for his own benefit all the capital stock of this company. The fact that this deal was made at the rate of $3 per acre, including the consideration for the proportional cost of the controlling works in the valley and of the main canal thereto from the Colorado River, for one of the very richest sections of land, shows plainly the financial straits of the company at that time.

PLATE CVI.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.



PLAN

SHARP'S HEAD-GATE
IN CENTRAL MAIN CANAL

Double lines represent sheet-piling 4"x 12". Tongued and Grooved.
Aprons are 2"x 12" flooring resting on pile foundations, outer edge depressed 2 feet.

(November) in 1906, and a total of 2 months in 1910, when there were shortages of water. Indeed, so accustomed are the water users of this region to obtaining all the water they want whenever they want it, that a suggestion of delivery in rotation—which is done in almost all irrigation projects—would doubtless meet violent opposition.

A preliminary summary, issued on December 15th, 1911, by the U. S. Census Bureau, states that, in 1909, 2 664 104* acres of land were irrigated in California, of which 220 000 acres, or one-twelfth, were in Imperial Valley. The percentage irrigated of the whole number of farms was 44.6, or 39 352 acres. The area included in projects completed and under construction was 5 490 360 acres, or slightly more than double the present irrigated area. Probably there will soon be 450 000 acres under the Imperial Valley canals, or just about the same proportion of one-twelfth. Of the acreage irrigated in 1909, there were 400 acres (0.01%) under the canals of the U. S. Reclamation Service; 3 490 acres (0.1%) under the U. S. Indian Service canals; 173 793 acres (6.5%) under canals of irrigation districts; 779 020 acres (29.2%) co-operative enterprises; 746 265 acres (28%) commercial enterprises; and 961 136 acres (36.1%) individual or partnership enterprises. Of the irrigated acreage in 1909, 71% was watered by works controlled by the water users. Of the remaining 29%, almost one-third is under the canals of the C. D. Co. Aside from the very large area covered by the canals of this project, its relative importance is vastly increased by the vital necessity for continuous service every day in the year, which has no counterpart of which the writer knows, and the minimum daily demand in winter is one-fourth of the maximum.

Obstacles Encountered by the C. D. Co.—The settlement of Imperial Valley† took place more rapidly than any of the men interested in the project had even hoped, and constituted the most marvelous achievement of irrigation in the West, up to that date at least, and probably to the present time. On January 1st, 1901, with the exception of a party of surveyors, not a single white man lived in the whole region; by January 1st, 1903, 2 000 people had come in; by January 1st, 1904, probably 7 000 people had made their homes in the new district, and by January 1st, 1905, the population was between 12 000 and 14 000. As early as 1904 there was a branch railroad through the district from the Southern Pacific main line at Old Beach, since called Imperial Junction, and, at the beginning of 1905, there were seven towns, with stores, banks, etc., 780 miles of canals, about 120 000 acres of land under actual cultivation, and 200 000 acres covered by water stock.

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* Undoubtedly, the greater part of this total is irrigated only after a fashion, so that the relative importance of the irrigated area in Imperial Valley is much greater than the figures indicate.

† The Imperial Land Company decided to use the name "Imperial Valley," for the region to be covered by the irrigation canals, instead of "Colorado Desert" or "Salton Basin," partly to distinguish between the reclaimed and unreclaimed areas, but chiefly for the effect of the name on readers of the colonization literature put out by the company. The name, "Imperial Valley," is firmly established as referring to the cultivated portion of the Colorado Delta west of the river, whether north or south of the International Boundary Line.

This unprecedented and unexpectedly rapid development overtaxed the resources of the C. D. Co., and, in addition, there were several untoward factors which accentuated the difficulty. These were serious complications in the United States Government Land Survey of the region, an extremely unfavorable soil report by the United States Agricultural Department, agitation for the United States Reclamation Service to supplant the irrigation system of the valley, a question as to the right to divert water from the Colorado River, and troubles at the intake by silt depositions.

United States Land Surveys in the Imperial Valley.—That portion of the Imperial Valley north of the 4th standard parallel was supposed to have been surveyed in 1854-56. The maps and notes for it were accepted, but there is at least some question whether the survey was ever actually made in the field. Later, in 1880, after the International Boundary Commission had surveyed the Boundary Line between the United States and Mexico and marked it continuously with permanent monuments, the area south of the 4th standard parallel was surveyed, this being locally known as the "Brunt" survey. The colonization company, in April, 1900, put out surveying parties under the direction of Mr. Perry, now County Surveyor of Imperial County, to re-run the Government lines and establish corners so that settlers might have proper descriptions for the tracts of land they wished to file on, and also that the distribution systems of the various mutual companies might be located along the Government subdivision lines, as the topography of the land is such that this ideal canal location is generally feasible. Mr. Perry found nearly all the corners of the Brunt survey, and used the notes showing certain connections made with the survey of 1856 along the 4th standard parallel. In this way

PLATE CVII.
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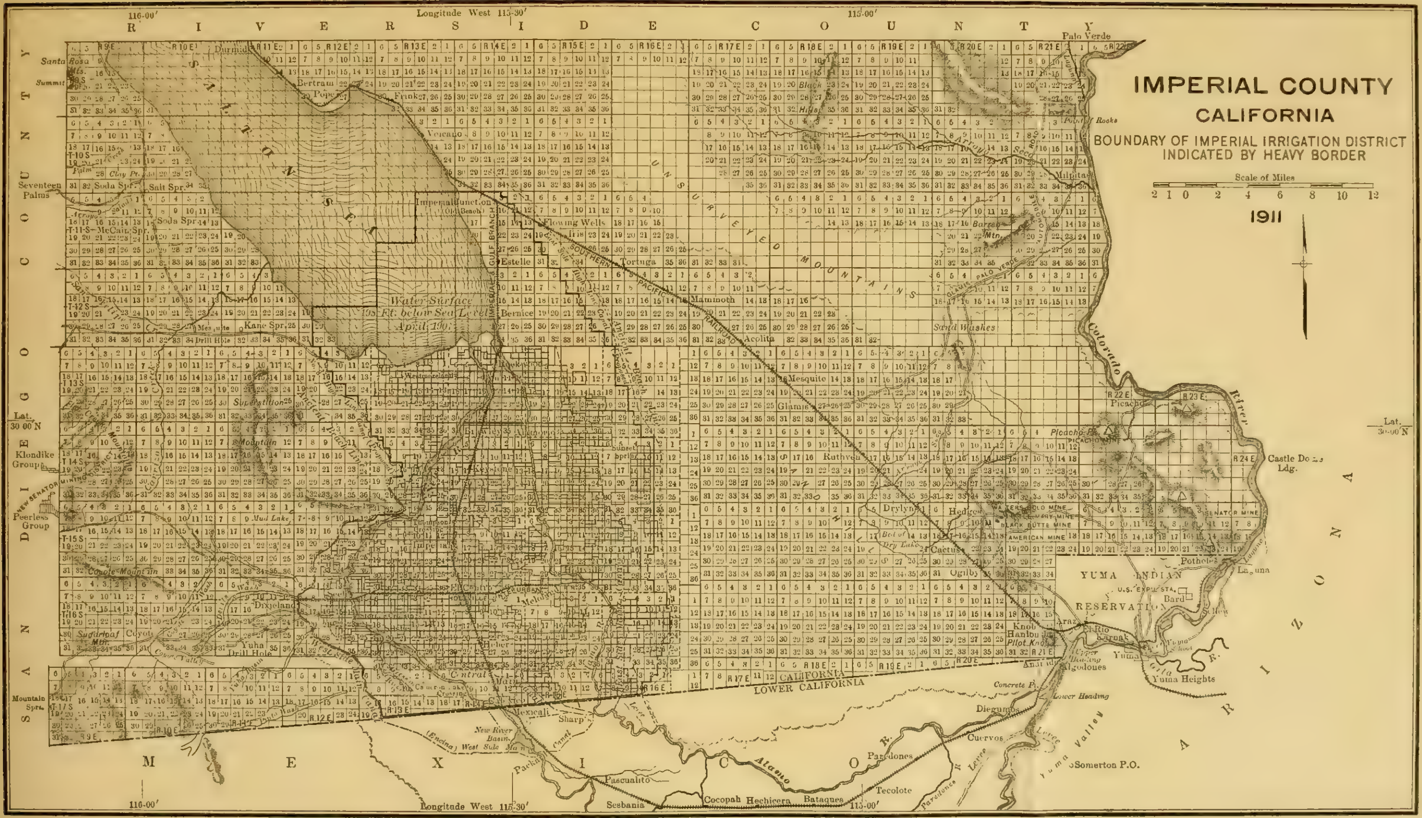
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.



the lines to the north were retraced, but, some time later, when the survey had extended farther and the work of retracing the lines east of the Alamo River was commenced, it was discovered, by encountering natural features given by the notes of the 1856 survey, 2 miles or more out of correspondence, that there were serious errors. Exhaustive search was then made for the 1854-56 survey stakes, but in an area of thirty townships only five corners were discovered which seemed to be authentic. These were widely scattered, and showed great errors. Between the 3d and 4th parallels the actual distance was found to be 25¼ miles, or an error of 1¼ miles in a 24-mile north and south line. East and west the error was approximately 2 miles in 30.

Throughout the territory, Sections 16 and 36, the school sections, had been given to the State of California by the United States Government for the benefit of the State school fund, the remainder of the land belonged to the United States, and this dual ownership increased the difficulty of making any adjustment. In June, 1902, the president of the colonization company and the chief engineer of the C. D. Co. went to Washington, explained the situation, and, on the advice of the General Land Office, an Act was prepared and passed in July, 1902, authorizing a resurvey of twenty townships of the land in Imperial Valley. The outside lines of these townships were re-run in 1903 and are known locally as the "Henderson" survey. It was more than 6 years, however, before the interior lines in these townships were re-run and the work was completed and approved.

In the mean time, it was impossible for the Land Office to issue patents to the settlers, and thus men practically owning from 160 acres to two and three times that area of extraordinarily fertile land, with a selling value of from $60 to $100 per acre, could offer no security for a loan with which to make permanent improvements. The United States land laws are extremely strict and severe with reference to a settler borrowing money with which to make final proof. Under such circumstances, the interest rate was naturally from 10 to 12% per annum, while the interest on deferred payments for the water stock was only 6%, so that the C. D. Co. suffered severely. However, it was not until 1909, more than 3 years after the control of the company was taken over by the Southern Pacific interests, that any suits were entered to foreclose on the collateral notes and mortgages secured by the water stock.

Soil Surveys of the Imperial Valley.—In the fall of 1901 the Bureau of Soils, United States Department of Agriculture, made a soil survey of Imperial Valley. On January 10th, 1902, a preliminary report, "Circular No. 9," was issued covering the 169 sq. miles of territory which had been examined.* The report doubtless presented the only possible conclusions, according to the information at that time extant regarding alkaline soils of such depth as are found in the Imperial Valley. It was very unfavorable, however, and calculated to deter sensible people from settling in the region. For example, one statement was as follows:

> "One hundred and twenty-five thousand acres of land have already been taken up by prospective settlers, many of whom talk of planting crops which it will be absolutely impossible to grow. They must early find that it is useless to attempt their growth. * * * No doubt the best thing to do is to raise crops such as the sugar beet, sorgum, and date palm (if the climate will permit), that are suited to such alkaline conditions, and abandon as worthless the land which contains too much alkali to grow those crops."

The warning was reiterated in a subsequent report.† It seems certain that, had the territory not been already settled in very large measure when these reports were sent out, Imperial Valley would yet be unreclaimed.

Agitation in Favor of a Reclamation Service Project.—When the United States Reclamation Service Act was passed, in June, 1902, the crops produced in the Imperial Valley were causing a return of confidence in the region, and the extraordinarily rapid development was being resumed. The irrigation possibilities on the Colorado River had already been examined by the United States Geological Survey, and in 1903 plans for the Yuma Project were outlined. The engineers of the Service were convinced that no diversion from the Colorado for irrigation could be permanently successful where provisions were not made for preventing the heavy silt from entering the canals—that it would take an impractically large amount of dredging to keep canals leading directly from the river open for reasonably satisfactory delivery of water. The cost of the Laguna Weir, borne by the land owners of Imperial Valley alone, constitutes a serious burden, but, if borne by all the irrigible land in both valleys, the cost per acre would be reduced to approximately one-fourth. Mr. William E. Smythe, of San Diego, who has been very prominent in the work of the National Irrigation Congress, and has written extensively on irrigation generally, urged the people of Imperial Valley to join with the Yuma Project; that the enterprise would then be backed by the Government with unlimited funds; that they would be required to pay to the Government only a small portion of the money they were obliged in one way and another to pay the C. D. Co., and that they would eventually acquire the laudable desire of owning and operating their own system. The Imperial Water Users' Association was accordingly formed with Mr. W. F. Holt, of Redlands, Cal., as its President, and negotiations were at once instituted with the C. D. Co. to acquire its canal system. Mr. A. H. Heber, President of the C. D. Co., who acted for it in the matter, knew that the estimates of the Reclamation Service for the canal line into Imperial Valley, lying entirely on American soil, were at least $10 000 000, on account of the sand hills. He believed that the Alamo River for 40 miles was a very satisfactory main canal, and that by owning the 100 000-acre tract of the Mexican Co., building another waterway through Mexican territory would require the consent of the Mexican Co.; consequently, his idea regarding the values of the property were excessively high.

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* "Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1901, p. 587."

† "Soil Survey of the Imperial Area, California (Extending the Survey of 1901), Advance Sheet of Field Operations of the Bureau of Soils, 1903."

As a natural feature of these negotiations, and with a view to tempering such ideas as to price, the right of the C. D. Co. to take water from the Colorado was challenged. The navigability of that stream suddenly assumed serious commercial, national, and international importance. As usual in such cases, these questionings were carried to unfortunate extremes.

In the course of events, at a mass meeting of the farmers in Imperial on July 30th, 1904, Mr. Heber offered to have the price fixed by arbitration, one man to be appointed by him, one by the Imperial Water Users' Association, and a third to be selected by these two. This was not done, but instead, the engineers of the Reclamation Service estimated the value of the plant of the C. D. Co. and the Mexican Co., making a report to the Secretary of the Interior on October 1st, 1904, a copy of which the writer has not yet succeeded in obtaining. On being advised by the Secretary of the Interior of the conclusion of such report, the Imperial Water Users' Association appointed a committee, headed by Mr. Holt, to negotiate with Mr. Heber, which was done, and a price of $3 000 000 was mutually agreed on. A petition was addressed to the Secretary of the Interior setting forth such action, and the committee of the Water Users' Association, together with Mr. Heber, as the duly authorized agent of the C. D. Co., went together to Washington to arrange matters accordingly. Soon after reaching Washington, however, the committee, without intimating to Mr. Heber in any way that it had changed its opinion, agreed with the Reclamation Service authorities against buying the property on such a basis.

With such unpardonable bad faith on the part of the committee, it is not surprising that the conference ended with relations between Mr. Heber and the Reclamation Service so strained that further negotiations were impossible. At that time it was announced by the Service that its legal department had concluded that no law existed whereby it could deal with the problem of carrying water through Mexico.

The effect of the entire incident was to render the people of the valley antagonistic to the company, and at the same time split them into several factions. More important, however, was the effect of the severe criticisms of the plant and water rights of the C. D. Co., which had been given wide publicity. The company's credit, which had slowly but steadily improved since 1902, was again destroyed in Southern California and in the larger financial markets of the United States. Consequently, early in 1905, when these negotiations ended, the company was almost on the rocks.

Water Rights Attacked.—Because of the attacks on the right to take water from the Colorado, then well under way, a bill was introduced into the House of Representatives in January, 1904, at the request of the C. D. Co., declaring:

"That the water of the Colorado River for the irrigation of the arid land that may be irrigated therefrom is hereby declared to be of greater public use and benefit than for navigation, and the diversion of the water from said river, heretofore made and that which may in future be made, for irrigation purposes, in accordance with the laws of the respective States and Territories in which such diversion has been or may be made, is hereby legalized and made lawful.

"Section 2. That any person, firm, or corporation be, and is hereby, authorized to divert, take, and appropriate water from the Colorado River for the purpose of irrigation, in such quantity, subject to and under the State appropriation of the State of California, as now in force under the laws of said State." (H. R. 13 627, 58th Congress, 2d Session.)

The U. S. Reclamation Service had filed on some of the flood-waters of the Colorado in order to fill four large reservoirs between The Needles and Yuma, then under contemplation, and such filings were practically second only to those of the C. D. Co., so that the effect of this proposed legislation, other than on the C. D. Co., was null. The bill was bitterly opposed by Mr. Smythe, as representing the majority of the settlers in Imperial Valley. No attempt was made to amend the bill with a view of protecting all interests in a fair and equitable manner, but instead, under date of April 8th, 1904, the Acting Attorney General, Mr. Hoyt, in an opinion addressed to the Committee on Irrigation on Arid Lands, to which the bill had been referred, said:

"In view of these provisions [from the Treaty of Guadalupe-Hidalgo, February 2d, 1848; of the Gadsden Purchase, December 30th, 1853; and the Boundary Treaty of November 12th, 1884, between Mexico and the United States] and of the important irrigation projects now and hereafter to be carried on by the United States Government, I seriously doubt the wisdom of a surrender by Congress at this time of all control over the waters of the Colorado River."

Accordingly, the Committee reported* requesting the Secretary of the Interior to investigate and report to Congress on the various questions involved in the use of the waters of the Lower Colorado River, with a view to determining their availability for irrigation, and recommend any legislation which might be necessary. This resolution failed to pass.

Mexican Concession Secured.—Failing to secure an adjustment of water rights at the hands of Congress, Mr. Heber went at once to Mexico and quickly obtained a concession from President Diaz, which was ratified by the Mexican Congress on June 7th, 1904.

This concession authorized the Mexican Co. to carry, through its canal system in Mexico, 284 cu. m. per sec. (approximately 10 000 sec-ft.), to be diverted from the Colorado River in United States territory by the C. D. Co. and turned over to the Mexican Co. at the boundary line; to construct an intake on Mexican territory, and connecting with the said canal system, and divert through such intake

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* House Joint Resolution No. 147.

284 cu. m. per sec., to be used in the irrigation of lands in Mexico and in the United States, but with the proviso, "without injuring the rights of any third party nor the navigation as long as the river is destined for navigation"; that, of the water carried in the canal, enough should be used to irrigate the lands in Mexico susceptible of irrigation by gravity to an amount not exceeding one-half the total volume; that the Mexican Co. should begin surveys within 6 months, and within 12 months file, with the Secretary of Development, maps in duplicate of the proposed extensions and betterments, together with a descriptive report, and entirely complete the same within 7 years; that the company should pay into the Inspection Fund, as is customary in all concessions granted by the Mexican Government, a sum, in this case $300 (Mexican money), per month, and should be subject to inspection by an engineer appointed by the Secretary of Development; granting the company the right of eminent domain over private property and defining the process by which condemnation could be carried out—incidentally with minimum possible difficulty—and permitting importation once for all, free of customs or duty, all equipment and apparatus necessary for the construction of the proposed extensions and betterments, together with freedom from all taxes, except stamp tax, for a period of 10 years; stipulating that under no circumstances should the company sell or mortgage the concession to any government or foreign state, nor admit it in partnership; that the company should be subject to the laws and rulings now in force, and which in future may be enacted, for the supervision and use of waters; particularly specifying that the company and its assigns shall always be considered as Mexican corporations, though all or any of its stockholders should be foreigners; that the corporation should be subject to the jurisdiction of the Courts of the Republic in all affairs emanating within Mexican territory, and that such stockholders should never be able to allege the rights of foreigners under any circumstances, but have the rights and the methods of establishing the same as the laws of the Republic grant to Mexican citizens, so that, in any matters, diplomatic or foreign agents should not have any interference.

Condition of Plant in the Summer of 1904.

From the first, there was a great deal of trouble with the Chaffey Head-gate, chiefly because its floor was not down to the bottom grade line of the canal, as originally planned. As has been explained, this gate was a temporary structure, but well and substantially built. Just as it was being covered up by the operations of the dredge, *Alpha*, cutting the main canal into the permanent concrete head-gate from below, in 1906, the writer examined it carefully and found it in an excellent state of preservation. The floor was so high, however, that it was necessary, during the low-water seasons of 1902-03 and 1903-04, to cut a by-pass around the gate, and close it on the approach of the summer floods. When the Mexican concession was obtained, the first Mexican intake was cut from the river to the main canal, as shown in Fig. 9.

In the winter of 1902-03 there had been shortages of water in the valley, due to the fact that the main canal had not been completed to its final depth; and, with the apparatus and available funds on hand, it was impossible to keep the water supply up to the demands when the river fell exceedingly low. In the winter and early spring of 1904, another water shortage caused considerable damage in the valley, and claims amounting to $500 000 were presented to the company. Every one of these was settled out of Court, however, in 1905 and the early part of 1906, with a payment of less than $35 000, taken entirely in water and water stock, and the writer believes that every claim was fairly settled, at least as far as the settlers were concerned.

Below the intake the first 4 miles of the Main Canal caused much worry, due to the extent to which it silted up during floods, but, with this exception, the plant of the C. D. Co. was in quite satisfactory condition. The canals were generally well located and in fair condition, and the structures, while of redwood and not concrete, were substantially built according to good design, and were in excellent condition. The canals in the distribution systems of the mutual water companies were silting up constantly, on account of the muddy water. In part, this was unavoidable, but was largely due to uneconomical methods of water deliveries when dealing with muddy water, particularly in serving any settler on his demand, regardless of the very low velocity, if no one else wanted water from the lateral during the same time. The silt problem in the distribution systems of these companies, however, is as simple as it will ever be for any lands irrigated along the Lower Colorado. The financial status of the various mutual companies was quite good, and they had generally established a small but satisfactory credit with the local banks.

To avoid excessive silt depositions in the first 4 miles of the canal, In February and March, 1904, the Best Waste-gate, so-called, was put in 8 miles below the intake, where water could be wasted from the Alamo channel through the Quail River into the Paredones River and thence into Volcano Lake. This was a wooden **A**-frame, flash-board gate, 60 ft. long, but it was carried away in June, 1906, by the side-cutting of the banks while the Alamo channel was being enlarged by that year's summer flood. The idea was to divert a large quantity of water during the flood season of 1904, waste it through the Best Gate, and in this way scour out the upper portion of the canal. At first the action was as expected, and some 2 ft. in the bottom were carried away. When the river reached its maximum height during the summer flood of 1904, however, and carried an excessive silt content, particularly of the heavier and sandy type, this scouring action was entirely overcome, and the bottom of this stretch was raised approximately 1 ft. higher than during the previous year.

The Silt Problem.—This action accentuated, and properly impressed on the engineers of the C. D. Co., the seriousness of the silt problem in diverting the Colorado River water. Generally speaking, during flood stages, the water carries all the silt it can transport, and the faster the current the larger the particles it picks up and carries along. It is certainly desirable, and probably essential, to provide settling basins at or immediately below the diversion point, in which water can be practically stilled and thus insure the deposition of the heavier silt having very slight fertilizing value, and the admission of only such partly clarified water into the canals. Unless some provision is made, as at the Laguna Weir, the diversion canal immediately below the head-gate must act as a settling basin, which is just what happened from the very beginning in the canals of the C. D. Co.

The results of such excessive silting were obviated in various ways, largely by the construction of new intakes, until the diversion of the entire river occurred, and the permanent head-gate was put in service in 1907. The clam-shell dredge, *Delta,* was utilized intermittently to remove the deposits until 1910, then a submerged weir was built across the river, to raise the water at the intake; and lastly large suction dredges were operated just below and just above the regulating gates.

Rather carefully kept records indicated that the bed of the canal at the Lower Heading was raised a little more than 5 ft. between March 1st, 1907, and March 1st, 1910, most of this taking place in the first 6 months. The bed of the Alamo near Sharp's Heading was raised approximately 2 ft. in the same time, and there is constant deterioration all along between these points on the Alamo channel. The reduction of capacity in the larger canals has been noteworthy, but the maximum effect is shown in the smaller laterals constituting the distribution systems of the various mutual water companies.

Mr. Robert G. Kennedy states* that on the Bari Doab Canal from the Punjab River, the canals in Sind from the Indus and Shwebo, and the Mandalay canals in Burmah, it appears that in a non-silting and non-scouring channel the mean velocity is independent of the width, but increases with the depth of the channel, according to the equation:

$$V_o = 0.84\, d^{0.64},$$

in which V_0 = the mean velocity of a non-eroding, non-depositing current; and d = the depth for fine sand-silt, the constants varying slightly with the kind of silt.

He also points out the exceedingly important deduction that during flood stages in the river, the diversion of large quantities of water in an effort to scour away silt depositions in the upper reaches of canals will have the opposite result, because of the excessive silt contents of the water diverted.

The same rule probably applies fully in the case of canals carrying Colorado River water when they are free of vegetation. In point of fact, however, rank growths of tules and willows spring up on the banks and berms and along the edges out into the water with such rapidity as to increase tremendously the deterioration of carrying capacity, particularly in the smaller canals. Furthermore, the rate of deterioration in these laterals increases with the decrease in channel efficiency. The maintenance of the district distribution systems, therefore, consists, in large part, in keeping down and removing the brush and tules.

The various distribution systems were ordinarily designed and built on the basis of a capacity of 1 sec-ft. per 120 acres of land there-under, although in some cases the ratio was decreased to 1 sec-ft. per 93 acres (8 in. vertical depth of water in a month). It would have been just as well, indeed considerably better, and of course cheaper, to have made the canals much smaller, for they were put into service when only a small percentage of the land was in cultivation, and, as they carried only a fraction of their capacity, they very soon silted up badly. Removing the silt deposition and the accompanying tule growths is fully as expensive as the excavation of the original section.

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* "The Prevention of Silting in Irrigation Canals," *Minutes of Proceedings*, Inst. C. E., Vol. CXIX, 1895, pp. 281-290.

This needlessly large excavation was required by the contract provisions under which the C. D. Co. built the distribution systems of the various mutual water companies, and such provisions at the time were necessary to assure colonists that the water supply would be ample. In the construction of the first lateral canals built, however, the leaving of inside berms was a defect which should have been avoided. These flat stretches, usually kept damp and seldom deeply submerged, afford ideal conditions for tule growths, and should be studiously avoided in this region.

Canal Maintenance.—In general, the best method of clearing away the brush tules and deposited silt in the smallest canals has been found to be by Mexican or Indian hand labor. The presence of checks and other canal structures at relatively close intervals makes the use of machinery of questionable economy. For the large canals, "V's", dragged by horses or traction engines, portable floating dipper-dredges, Lidgerwood cross-drags, portable clam-shell dredges, and a number of devices designed by local inventive geniuses have been tried with varying success. The results in all cases depend so greatly on the efficiency with which they are handled and the local conditions under which they work that it will not be profitable to attempt to give any cost figures—indeed, with the exception of Imperial Water Company No. 1, no cost-keeping worthy of the name has been attempted.

Perhaps the most satisfactory appliance for cleaning canals too small for floating dredges is a clam-shell bucket arranged on wheels so that it may follow along the bank. (Fig. 1, Plate CVIII.) The C. D. Co. has two of these machines, manufactured by the Stockton Iron Works, Stockton, Cal., which cost $5 000 each, f. o. b. factory. These consist of a clam-shell bucket having a capacity of 15 cu. ft., with a 40-ft. steel boom carried on an all-steel frame. The maximum width is 14 ft. The power is supplied by a 15 h.p. Atlas gasoline

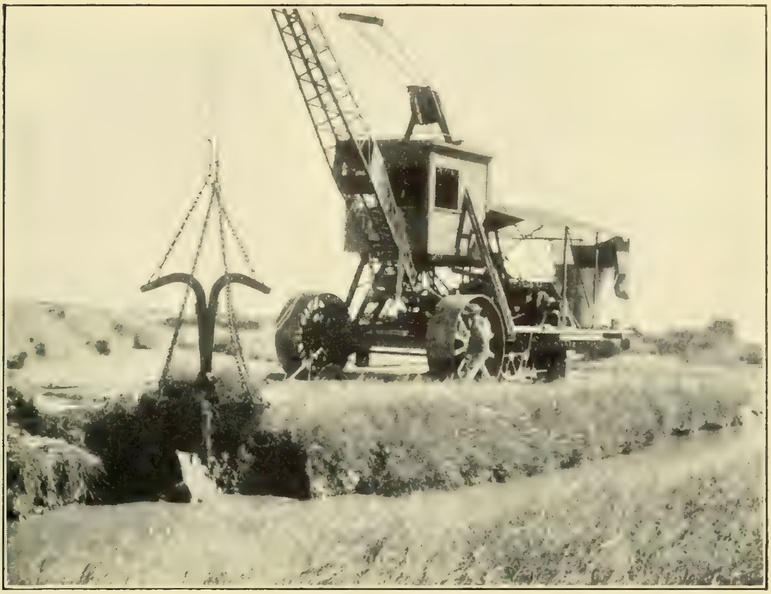

FIG. 1.—STOCKTON CLAM-SHELL DREDGE CLEANING CANALS IN IMPERIAL VALLEY.

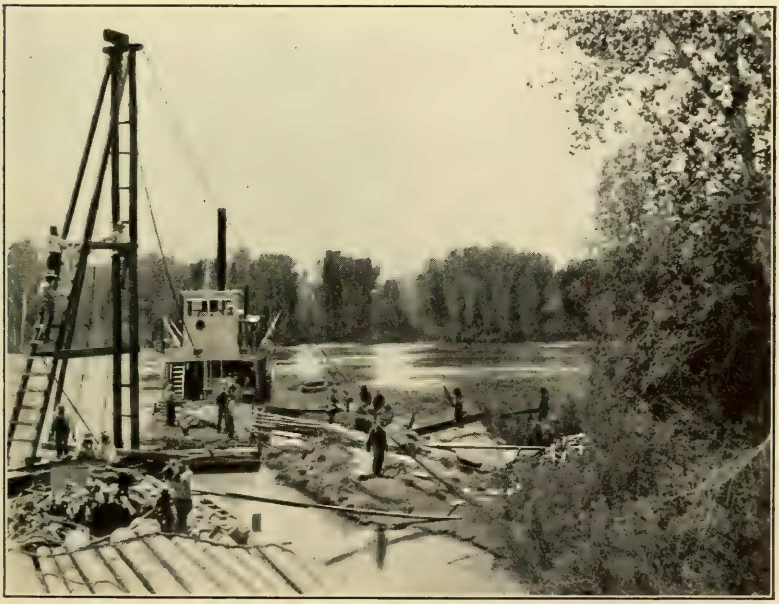

FIG. 2.—THIRD ATTEMPT TO CLOSE BREAK AT LOWER MEXICAN INTAKE, JUNE 1ST, 1905.

engine, manufactured in San Francisco, and the machine is self-propelling, with two speeds forward and one reverse. No definite figures, including deterioration and cost of moving from one job to another, are available, but it is understood that the cost of handling material with these machines is about 13 cents per cu. yd.

For handling silt in the upper reaches of the Main Canal along the river, the large 4-yd. dipper dredge, *Alpha,* used in the original construction, was perhaps the most efficient of all agencies for the first few years until the waste banks along the canal became too high to permit of its further use; it handled material for about 6 cents per cu. yd. A suction dredge, the *Beta*, equipped with a 12-in. Kroh centrifugal pump—manufactured in San Francisco—was tried very soon after the canals were put into service, but too much difficulty was caused by roots clogging the pipes and machinery. Mr. H. W. Blaisdell, of Los Angeles, one of the principal stockholders of the C. D. Co., devised a rotary cutter for use at the end of the suction pipe, but it was not successful. This dredge was used at the Lower Heading, in the construction of the Rockwood Gate, and in the subsequent diversion work until June, 1907, when it was dismantled.

In the central main in the valley, and also in the Alamo channel just above Sharp's Heading, a 2-cu. yd. dipper dredge, *Gamma,* has been used almost continuously since it was put in operation in 1904, removing material at about 5 cents per cu. yd.

The clam-shell dredge, *Delta,* described in some detail later, has done excellent service in silt removal and incidental levee building, as well as in channel straightening, since its arrival on the work in November, 1906. It is now engaged in building cut-offs and making general channel improvements, rather than removing the silt deposits direct.

In the summer of 1910 an arrangement was entered into between the various mutual water companies combined and the Receiver of the C. D. Co. whereby the former was to furnish the money and build a suction dredge and rent it to the latter for 10% annually on its first cost. This dredge was built just below the concrete head-gate, and its operation is confined to the American side of the line, the contract being entered into with the North American Dredging Company, of Los Angeles, on December 10th, 1910, for the construction and equipment of an exact duplicate of one of the latter company's dredges in

San Pedro Harbor, for $57 300. After being put into service it was found necessary to remodel the upper deck, in order to make the quarters of the crew suitable for the climatic conditions, at a cost of $950, and a bonus of $2 200 was paid for completion 11 days ahead of the contract time—4 months—making the total cost $60 450, exclusive of engineering, inspection, and legal expenses, which brought the grand total cost up to approximately $63 600. This dredge, the *Imperial,* has a hull 105 ft. long, 55 ft. wide, and 8 ft. deep, and is equipped with a 15 by 60-in. Kroh centrifugal pump driven by a vertical compound engine, steam being supplied by a 250-h.p. marine-type boiler. This dredge handles the silt deposits in the enlarged section of the canal below the head-gate at the rate of about 200 cu. yd. per hour lifted to an average height of 35 ft., at a cost of from 5 to 7 cents per cu. yd., exclusive of interest, taxes, and depreciation, using crude oil fuel at $1.40 per bbl., equivalent to coal at $5.60 per ton.

The *Imperial* was equipped with a cutter for stirring up the material, but this was found to be unnecessary for handling the silt deposits just below the head-gate, and the cutter engine, of vertical compound type, with 8 by 15 by 10-in. cylinder, was installed on the barge, *Silas J. Lewis,* mentioned later, in the canal above the head-gate to run the 10-in. Kroh pump formerly on the *Beta,* the resulting dredge being known as the *El Centro.* Under like conditions, the cost of handling material with the *El Centro* is approximately the same as with the *Imperial.*

With these two suction dredges, it is claimed that the bed of the Main Canal has been lowered approximately 5 ft. above and at the head-gate and for a distance of 3½ miles below, diminishing gradually to nothing throughout the next 2½ miles. If future experience confirms such results, it would seem that the periodic dredging of silt depositions from a settling basin near the intake, at a cost of from $30 000 to $40 000 per annum, will solve the silt problem in the Imperial Valley canal system, except for the very fine silt which cannot be gotten rid of except by allowing the water to be quiescent for some time.

The following general cost figures on maintaining the 373.25 miles of canals of the distribution system of Imperial Water Company No. 1 during 1911 are taken from the annual report of the Superintendent, R. S. Carberry, Assoc. M. Am. Soc. C. E.

Cleaning 465 miles of canal cost $60.64 per mile. The figures in 1910 are 562 miles at $43.81 per mile, and the average cost for the last 6 months of 1909 was $73.16. Clearing on 194 miles of canal cost $35.39 per mile. Cutting brush on 392 miles cost $20.71 per mile. The figures in 1910 were 346 miles at $43.47 per mile, and $60.65 per mile for the last 6 months of 1909.

In this report it is stated that canal "V'ing" is the best method for cleaning canals, generally speaking, and the company owns three "V's", each costing about $600, and three caterpillar traction engines to operate them, each costing $4 200. During the year, 363.8 miles of canal were "V'd" at $58.91 per mile, as compared with 362 miles in 1910 at $60.74 per mile, the details being as follows:

"V'ing"	$16.76
Repairs to engines	16.29
Repairs to "V's"	5.00
Fuel and oil	5.96
Mexican labor following "V's"	14.80
Total average cost per mile	$58.91

During the year, 1 415 miles of canal were worked on, so that the whole system was covered in various ways nearly four times during the year. A small portion of the system was not worked on at all, so that this statement gives some idea of the difficulty in maintaining the system.

The cost of building 117 new structures was $6 278.75, and the cost of repairing old structures was $4 145.05, making the total cost of structure maintenance and renewal $10 423.80. The average number of men employed per day (300 working days per year) was 162, or 0.43 man per mile of canal per day, in addition to teams and machinery. The bottom width of the canals constituting this system varies from 20 to 5 ft.

Canal Operation.—The mutual water companies have never considered delivering water to stockholders in rotation, but instead, without exception, supply any water user on demand, even though he may be at the very end of a long lateral and the only person desiring water from that lateral at the time. Thus, naturally, exceedingly small quantities of water are carried occasionally in every canal except the very largest laterals, and the result is low velocities and heavy silt deposition and canal deterioration. The feeling seems to be general that the additional cost of maintaining the various distribution systems is more than offset by the advantages or convenience of the water users in obtaining irrigation water at all times on 24 hours' notice. The amount which the maintenance cost of canals could be cut by adopting a rotation system of delivery is problematical, but must be between 35 and 65 per cent. This fact should be borne in mind in making comparisons with the cost data just given.

THE FOURTH OR LOWER INTAKE.

This is such a very important matter that the reasons for digging the lower Mexican intake and the method of handling it when completed are given by quoting from Mr. Rockwood,* the man who did it.

"As soon as the summer flood (1904) dropped and I discovered that instead of the bottom being lower it was approximately 1 ft. above that of the year previous, we adopted the only means at our command to attempt to deepen the channel.

"Knowing the character of the material to be removed, we knew that with the dredging tools which we had (4-yd. dipper dredge *Alpha* and 12-in. suction dredge *Beta*), it would be impossible to dredge out this 4 miles of canal in sufficient time for the uses of the valley, providing the water in the river should drop as low as it had the previous year. The dredges were brought back, however, and put at work, but the result proved, as I had anticipated, that it would take practically all winter to dredge the canals; that is, it would take all winter to provide new machinery, even if we had the money; and in hopes, then, that it might possibly prove effective, I employed the steamer *Cochan*, and, placing a heavy drag behind it, ran it up and down the canal in hopes that by stirring up the bottom there would be sufficient velocity in the canal itself to move the silt deposits on below the 4-mile stretch to a point where I knew the water had sufficient velocity to keep the silt moving. A month's work, however, with the steamer proved that the work being done by it was inadequate.

"*The Great Problem.*—We were confronted then with the proposition of doing one of two things, either cutting a new heading from the canal to the river below the silted 4-mile section of the canal, or else allowing the valley to pass through another winter with an insufficient water supply. The latter proposition we could not face for the reason that the people of the Imperial Valley had an absolute right to demand that water should be furnished them, and it was questionable in our minds as to whether we would be able to keep out of bankruptcy if we were to be confronted by another period of shortage in this coming season of 1904-1905.

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* "Born of the Desert—Imperial Valley In Its Making Not A Dream—A Brief History of the California Development Company." By C. R. Rockwood. Second Annual Magazine Edition, *Calexico Chronicle*, Calexico, Cal., May, 1909.

"The cutting of the lower intake, after mature deliberation, and upon the insistence of several of the leading men of the valley, was decided upon. We hesitated about making this cut, not so much because we believed we were incurring danger of the river's breaking through as from the fact that we had been unable to obtain the consent of the Government of Mexico to make it, and we believed that we were jeopardizing our Mexican rights should the cut be made without the consent of the Government. On a telegraphic communication, however, from our attorney in the City of Mexico, to go ahead and make the cut, we did so under the presumption that he had obtained the necessary permit from the Mexican authorities. It was some time after this, in fact after the cut was made to the river, before we discovered that he had been unable to obtain the formal permit, but had simply obtained the promise of certain officials that we would not be interfered with, providing that plans were at once submitted for the necessary controlling structures to be placed in this heading.

"*Reasons Why.*—This lower intake was constructed, not, as is generally supposed, because there was a greater grade from the river through to the Main Canal at this point. The grade through the cut and the grade of the Main Canal above the cut were approximately the same, but the cut was made at this point for the reason that the Main Canal below the point where the lower intake joined it, was approximately 4 ft. deeper than the Main Canal through the 4 miles above this junction to the Chaffey gate, consequently giving us greater water capacity. In cutting from the Main Canal to the river at this point, we had to dredge a distance of 3 300 ft. only, through easy material to remove, while an attempt to dredge out the Main Canal above would have meant the dredging of 4 miles of very difficult material. We began the cut the latter end of September and completed it in about 3 weeks.

"As soon as the cut was decided upon, elaborate plans for a controlling gate were immediately started and, when completed early in November, were immediately forwarded to the City of Mexico for the approval of the engineers of the Mexican Government, without whose approval we had no authority or right to construct the gate. Notwithstanding the insistence of our attorney in the City of Mexico and various telegraphic communications insisting upon this approval being hurried, we were unable to obtain it until 12 months afterward, namely, the month of December, 1905.

"*Unprecedented River Conditions.*—In the meantime serious trouble had begun. We have since been accused of gross negligence and criminal carelessness in making this cut, but I doubt as to whether any one should be accused of negligence or carelessness in failing to foresee that which had never happened before. We had before us, at the time, the history of the river as shown by the daily rod readings kept at Yuma for a period of twenty-seven years. In the twenty-seven years there had been but three winter floods. In no year of the twenty-seven had there been two winter floods. It was not probable, then, in the winter of 1905, that there would be any winter flood to enlarge the cut made by us, and without doubt, as it seemed to us, we would be able to close the cut before the approach of the summer flood by the same means that we had used in closing the cut for three successive years around the Chaffey gate at the head of the canal.

"During this year of 1905, however, we had more than one winter flood. The first heavy flood came, I believe, about the first of February, but did not enlarge the lower intake. On the contrary, it caused such a silt deposit in the lower intake that I found it necessary, after the flood had passed, to put the dredge through in order to deepen the channel sufficiently to allow enough water to come into the valley for the use of the people.

"This was followed shortly by another heavy flood that did not erode the banks of the intake, but, on the contrary, the same as the first, caused a deposit of silt and a necessary dredging. We were not alarmed by these floods, as it was still very early in the season. No damage had been done by them, and we still believed that there would be no difficulty whatever in closing the intake before the approach of the summer flood, which was the only one we feared. However, the first two floods were followed by a third, coming some time in March, and this was sufficient notice to us that we were up against a very unusual season, something unknown in the history of the river as far back as we were able to reach; and, as it was now approaching the season of the year when we might reasonably expect the river surface to remain at an elevation that would allow sufficient water for the uses of the valley to be gotten through the upper intake, we decided to close the lower.

"*Five Floods in One Season.*—Work was immediately begun upon a dam similar to the ones heretofore successfully used in closing the cut around the Chaffey gate. The dam was very nearly completed, when a fourth flood coming down the river swept it out. Work was immediately begun on another dam which was swept away by the fifth flood coming down during this winter season."

These closings of the by-passes or cuts around the Chaffey Gate were effected by throwing a barrier of brush across the cut and dragging earth over it with Fresno scrapers, pushing it into the water on the up-stream side, thus gradually rendering the barrier impermeable and then building it up as an earthen dam. In attempting to make the closure here mentioned, in March a small pile-driver was rigged up on the end of the *Alpha* and one line of 8 by 8-in. pine timbers, 3 ft. apart, was driven across the opening about 3 000 ft. west of the river bank, and an 8 by 8-in. waling was bolted to each pile above the water surface. Brush fascines were then made up, and all the sand bags available—about 10 000—were filled in readiness. Simultaneously from each side, brush fascines with the brush ends up stream, were piled above the piling and weighted down with sand bags, making alternate layers of fascines and bags, until the water was confined to a 30-ft. channel in the center. This barrier was about 20 ft. thick up and down stream. The opening was then spanned with long cottonwood timbers and a similar brush-sand-bag construction was built upon them. The supporting timbers were then shattered with dynamite, letting the mass drop into the opening. At the same time a large quantity of brush was thrown in above and allowed to float into the opening to help close it. In this way the barrier across the opening was built above water and teams passed over it dragging in dirt from both sides, the flow being reduced so greatly that the dredge below it nearly went aground. With a few thousand more sacks of earth to place along the upper toe of the barrier, the work would have been successful. As it was, the structure was undermined, settled down, and eventually failed entirely.

In this attempt 10 000 sacks were used, 8 days' time with the dredge at $100 per day, and 225 men-days time of Indian labor at $1.50 per day. This makes the total cost of closing about $1 800.

Instructions were then given to move the dredge up close to the river bank, where the soil was thought to be better, and make another attempt. The current through the break, however, was too swift, and instructions were given to go up the old Main Canal to the upper Mexican intake to stop it, which was done, using the method which had failed below.

A similar method was used to throw the water through the Alamo Waste-gate on its completion in June, 1905, 3 months later, 30 000 sacks of earth being filled in readiness and every one used. This barrier dam was thrown across the channel carrying 2 500 sec-ft. of water and with a total or final head of 10 ft. This has always seemed to the writer to have been a most remarkable achievement, the only equipment at hand being a skid pile-driver and Fresno scraper teams.

To resume Mr. Rockwood's narrative:

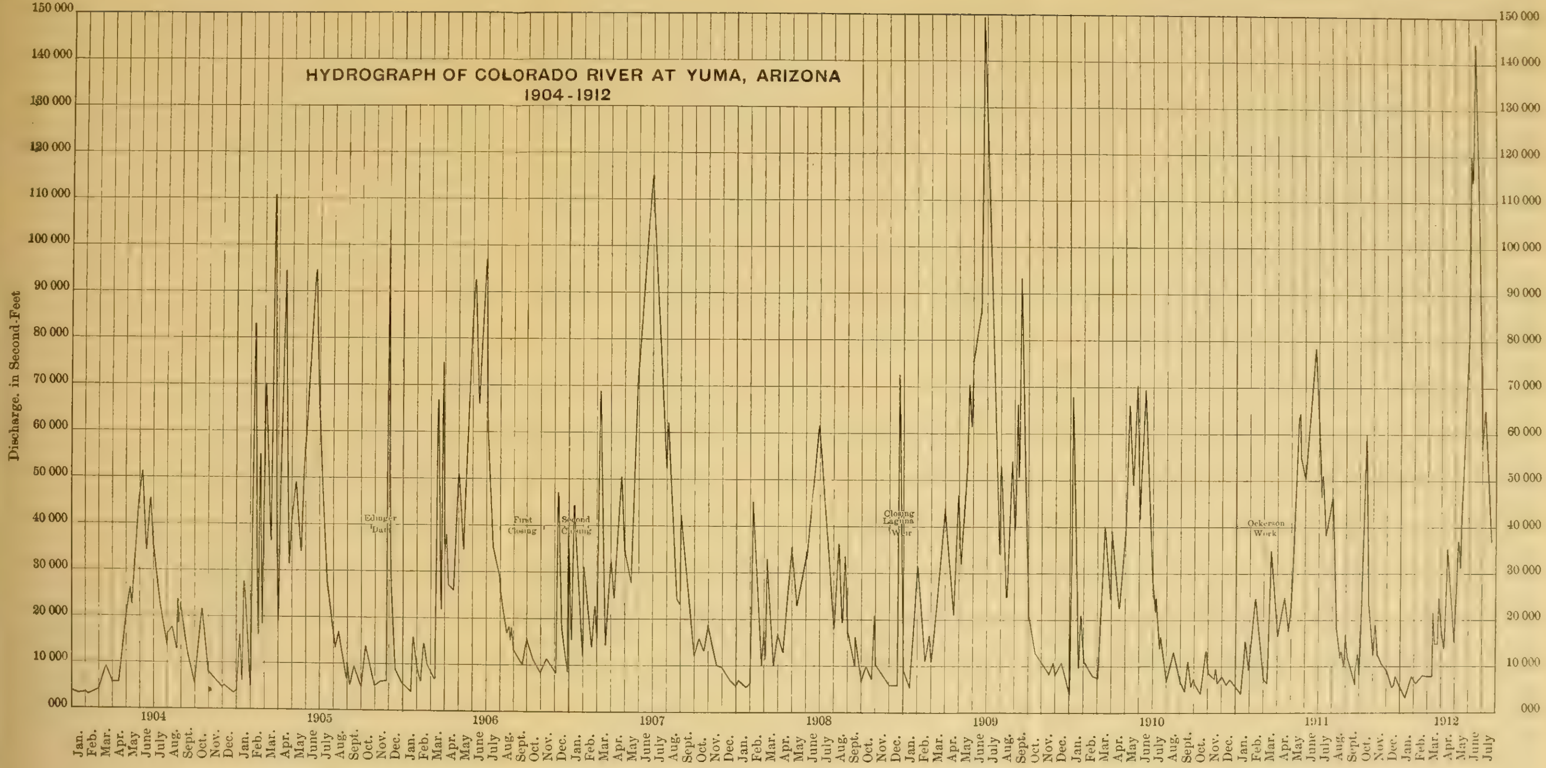
"About this time, I left for the East and at the earnest solicitation of the Imperial Water Company No. 1, which agreed to advance $5 000 for the effort, a third attempt to close the break was made under the direction of Mr. C. N. Perry and the superintendent of Imperial Water Company No. 1, Mr. Thomas Beach. On my return from the East, on the 17th of June, I found them heroically attempting to stop the break, with the waters so high in the Colorado that all of the banks and surrounding lands were flooded, and I immediately stopped the work as we realized fully that nothing could be done until after the summer flood had passed.

"*The Colorado on a Rampage.*—At this time, the lower intake had been enlarged from a width of about 60 ft., as originally cut with the dredger, to a width of possibly 150 ft., and it did not then seem probable that the Colorado River would turn its entire flow through the cut, but as the waters of the river began to fall, the banks of the intake began to cave and run into the canal, the banks of the canal below the intake fell in and, as known by most of the residents of the valley, the entire river began running through the canal and into the Salton Sea in the month of August of this year of 1905."

Plate CIX shows the discharge at Yuma to have been an unprecedented sequence of floods from the Gila water-shed. Indeed, the precipitation throughout all that region traversed by the Southern Pacific line from Yuma to very near El Paso during this period was quite without precedent. Track ballasted with local material, which had always proved satisfactory, was during this year the despair of the entire Maintenance of Way Department, and for months trains were allowed to go over it only at half speed and with lurchings of the coaches and Pullman sleepers like ships at sea.

Mr. Rockwood's statement gives a very fair presentation of the matter as he viewed it. The writer is perhaps as well aware as any one that the river was diverted through this cut into the Salton Sea, and when he first inspected the situation in August, 1905, he felt, like practically all other engineers who gave the matter cursory consideration, that making this cut was a blunder so serious as to be "practically criminal." After 4 years of more or less bitter experience with the region, he is perfectly convinced that, matters having gotten into such condition, making the cut was absolutely imperative and by all means should have been done. The difficulty had not been any tendency whatever to divert the entire river, but—very much to the contrary—

PLATE CIX.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.



HYDROGRAPH OF COLORADO RIVER AT YUMA, ARIZONA
1904-1912

to induce enough water to go that way. Up to that time, a head-gate to prevent too great a quantity of water from entering the canals was of far less importance than some means of maintaining their carrying capacity. That a head-gate should have been provided is, of course, self-evident. It would have been utter folly, however, to have put a flash-board gate of any type directly in the diverting channel, because of the drift which would have accumulated against it. Nothing less than a structure containing immense openings could have been used without insuring that the cut would be choked up. This type of construction was practically unused in western irrigation works at the time, and would have cost a great deal of money, therefore, considering the financial condition of the C. D. Co., it is plain that the only practical thing would have been a gate, not in the cut itself, but in a by-pass, and built with the idea of closing the by-pass on the approach of the summer floods and using this gate as much as possible. It was not alone the straitened financial condition of the C. D. Co. and the situation generally in which it found itself which resulted in there being no permanent diversion works put in; two other important factors entered. The first was the practical change of management, from a construction point of view especially, to the Chaffeys in the summer of 1900; back to Mr. Rockwood in February, 1902, and internal difficulties in the C. D. Co. late in 1904. The second—indirectly connected with the first—was the hesitancy of the management to provide permanent head-works before the technical men in the corporation had agreed as to what the situation demanded. The real mistakes was not in "putting all the eggs in one basket," but in not "then watching that basket." Obviously, no one could be responsible for doing such a thing without realizing the need for watching it most carefully and being fully prepared to take most aggressive action should occasion arise.

Southern Pacific Loan.—Early in January, 1905, it occurred to the management of the C. D. Co. that the phenomenal development of traffic furnished to the Southern Pacific Railroad by the Imperial Valley warranted the hope of financial assistance from that corporation. Mr. Julius Kruttschnitt, Director of Maintenance and Operation of the Harriman Lines, declined to consider the proposition, but Mr. Harriman, on being approached, was at once interested and ordered an investigation and report. As a final result, the Southern Pacific

Company agreed to loan $200 000 on condition that 6 300 shares of the capital stock be placed in the hands of a trustee to be named by the Southern Pacific Company until the loan should be repaid, and taking over the management of the property until that time. Accepting a loan under such conditions was seriously objected to by a large part of the company's stockholders, but at the annual meeting in Jersey City, in May, a board was elected pledged to the arrangement. On June 20th, 1905, the Southern Pacific Company took over the management of the property, with Mr. Epes Randolph, President of the Associated Harriman Lines in Arizona and Mexico, as President, and Mr. W. J. Doran, of Los Angeles, as the trustee mentioned in the contract. Both these gentlemen are still acting in these respective capacities. When the loan was arranged, and even when it was finally consummated, the railroad officials in San Francisco and the East did not consider the conditions along the river worthy of serious concern.

Mr. Rockwood was retained temporarily as Assistant General Manager and Chief Engineer, as members of the Southern Pacific management were entirely unfamiliar with the affairs of the C. D. Co.

FOURTH ATTEMPT TO CLOSE THE BREAK.

As soon as the summer flood of 1905 began to recede, work was started. Immediately opposite the lower intake was an island, later dubbed Disaster Island, about $\frac{5}{8}$ mile long and $\frac{1}{4}$ mile wide, consisting really of a sand bar on which quite a growth of cottonwood and arrow weed had accumulated. A line of piling, 12 ft. from center to center, was driven from the upper end of this island to the Mexican shore, as shown in Fig. 12, and between this piling was woven barbed wire and brush. The theory behind this work was that, by spreading over a great width the water passing down the west channel and into the lower intake, a sand bar would be created, thus choking off the flow and gradually forcing all the water into the east channel. On July 15th about one-third of the river flow was going down the old channel and two-thirds toward the Salton Sea, and the result of this endeavor was still problematical. By August 1st a bar, approximately 2 800 ft. long, had been formed, but there was an opening, approximately 125 ft. long, through which the rush of water was too great to be controlled with the means at hand, and the work was abandoned. Up to this date, about $30 000 had been expended on the four endeavors to close the break.

Various Suggestions for Handling the Situation.—At this time it was evident to all that the low-water flow of the Colorado would be entirely diverted into the old Alamo overflow channel and thence to the Salton Sea. The elevation of the water surface at the head of Disaster Island, with a flow in the river of 10 000 sec-ft., was approximately 100 ft., while the bottom of the Salton Sea is approximately — 287 ft., making the total fall in that direction 387 ft. The distance was about 95 miles by the watercourses, so that the average fall was 4.01 ft. per mile. Toward the Gulf the fall was 100 ft., and the distance to tide-water was approximately 80 miles, or a fall of 1.25 ft. per mile. The continually diminishing quantity of silty water going down the old channel as the summer flood receded was constantly raising the bed along that direction, the action being rapid enough to be noticeable almost daily. In all probability there were about 6 months ahead during which the flow of the water would be low, and before this period should elapse the river must be re-diverted or the consequences would be most serious.

The plant and the salt deposits of the New Liverpool Salt Company in the bed of the Salton Sea were already entirely submerged, the water covering about 100 000 acres, with a maximum depth of about 16 ft. Except for the increase of depth and the consequent increase in the length of time this property would be shut down, no additional damage was really being done at this point. Indeed, 14 years earlier, this property was covered to a depth of 6 ft. by the great flood of February, 1891, and the summer flood following, and in all probability a similar and greater inundation would have resulted from the excessive floods during the spring and summer of 1905 had the C. D. Co. never constructed any works along the river. The rising waters of the Salton Sea were threatening the tracks of the Southern Pacific Railroad along the east side of the sink, and the officials of the Los Angeles Division were clamoring for aggressive action. The higher officials of the company, however, were not yet very much perturbed. On the other hand, the Alamo channel was being enlarged and deepened, to the very great benefit of the C. D. Co., and the irrigation system of Imperial Valley, because the insufficient carrying capacity of this channel and the heavy silt deposits therein constituted a serious menace to the entire project.

To close the lower intake entirely meant obtaining all the water required for the irrigation of Imperial Valley through the 4 miles of badly silted Main Canal lying between it and the upper intakes, and this was out of the question. Even with large sums of money, which might be obtainable from the Southern Pacific interests, machinery could not have been bought, assembled, and put into operation in time to have permitted the delivery of more than enough water to supply the inhabitants and live stock of the valley with drinking water if the river flow should be reduced to 6 000 or 7 000 sec-ft. Imperial Valley at that time consisted of at least 125 000 acres under cultivation, five towns with an aggregate population of 2 500 people, and a rural population of approximately three times that number. There were, perhaps, 100 000 head of hogs, 50 000 head of cattle, and other live stock in proportion.

Many plans were suggested, from this time, August 1st, 1905, until the break was finally closed in 1907. Many of these, of course, were thoroughly absurd, and came from cranks and people who had not the faintest conception of the conditions. Indeed, almost the only people who appeared to be able to see that the problem was not merely one of shutting off the lower intake were the engineers of the C. D. Co. and a few of the well-informed men in Imperial Valley. Representatives of the New Liverpool Salt Company, the Southern Pacific Company, various departments of the United States and Mexican Governments, and the general public, all joined in demanding aggressive action to stop the menace of a new Salton Sea.

Such suggestions were addressed to Mr. Harriman and to nearly every other official of the Southern Pacific interests, and to Mr. Randolph and other authorities of the C. D. Co. Ultimately, most of these found their way to the writer; they constitute a most interesting collection. It is not profitable to mention more than four of these suggestions, which may be designated the Laguna Weir Plan, the Concrete Head-gate Plan, the Rockwood Head-gate Plan, and the Barrier Dam Plan. Edwin Duryea, Jr., M. Am. Soc. C. E., also offered to close the break according to a plan, which, however, he declined to outline.

The Laguna Weir Plan.—The Laguna Weir Plan consisted in abandoning operations for the time being at the scene of the break; concentrating all efforts on the completion, at the earliest possible date, of the Laguna Weir, which was being built by the U. S. Reclamation

Service; building a canal thence passing Pilot Knob and intersecting the break from ½ to ¾ mile west of the Colorado River, this canal to have a capacity equal to the low-water flow of the river; then diverting all the river water through this canal; finally, to build a dam across the intake between the canal junction and the river bank in still water. The Laguna Weir was actually completed in the early spring of 1909, just before the annual record flood of that year. It is not clear just how its completion could have been essentially hurried. Had this plan been followed, the Colorado would have emptied into the Salton Sea for 3 years longer than it actually did, and during this time 55 000 000 acre-ft. of water went by Yuma, only a very small portion of which would have gone down the old channel to the Gulf. This would have raised the water in the Salton Sea to the 180-ft. contour, with the effect of drowning out a large area of cultivated land in the Coachella Valley and forcing the abandonment of 60 miles of main line track by the Southern Pacific Railroad.

These effects, however, would have been of relatively minor importance. The irrigation system of Imperial Valley would have been strained far beyond the breaking point in several places, while the cutting back in New River would unquestionably have reached the Alamo channel and lowered the water therein far beyond the point where any could have been gotten into the Imperial Valley by gravity. This, of course, would have meant the depopulation of that region, an appalling result, without parallel in history.

The Laguna Weir Plan is thus seen to have been impracticable, and no one actually connected with the work gave it serious consideration. Nevertheless, it was urged on Mr. Harriman by Mr. C. D. Walcott, then Director of the United States Geological Survey and of the Reclamation Service, and Mr. Harriman considered it for quite a time.

Concrete Head-gate Plan.—The Concrete Head-gate Plan was put forward by the late James D. Schuyler, M. Am. Soc. C. E., who acted as Consulting Engineer of the C. D. Co. from July, 1905, to June, 1906. It consisted essentially of building a reinforced concrete and steel head-gate on the Pilot Knob site, where solid rock foundation could be secured, such gate to be able to carry the low-water flow of the river; and then, from this head-gate down to its junction with the crevasse, to enlarge the canal to a similar capacity. This, it was considered, would permit the diversion of all the water through the head-gate and canal, leaving the river below, and consequently the break itself, dry. The underlying idea was somewhat similar to that of the Laguna Weir Plan, except that it contemplated only 4 miles of canal enlargement and a diversion structure which could be completed in 3 or 4 months, instead of 3 years.

This plan involved the construction of permanent head-gates on rock foundation at Pilot Knob, so long contemplated; and the construction and equipment of a dredge with which the requisite 4 miles of canal could be dug economically and quickly. The idea was adopted in a tentative way in September, 1905, approximately 90 days after the Southern Pacific Company undertook the management of the C. D. Co., and Mr. Schuyler was instructed to proceed with the preparation of plans for the head-gate, while Mr. F. S. Edinger, under whose direction the Edinger Dam was built, arranged for the dredge. At the suggestion of the Golden State and Miners Iron Works, of San Francisco, the clam-shell type, with 150-ft. boom and 5-cu. yd. bucket, was selected. Work was begun on the concrete head-gate on December 15th, 1905, and contracts for the clam-shell dredge were arranged a few weeks later.

One of the chief recommendations of this plan was that the constructions, in large measure, would be permanent. It was assumed that, while perhaps the maximum quantity of water which would have to be diverted for the irrigation of Imperial Valley would never exceed 5 000 sec-ft., a gate twice as large would not have any particular disadvantages in its maintenance or operation. It was urged, further, that this arrangement of diverting structure and large canal would be available in case of future breaks, should any ever occur.

The difficulty about the plan was that, regardless of the size of the gate, enlarging the 4 miles of canal to carry 10 000 sec-ft. within sufficient time to afford reasonable relief was a very serious problem, while the capacity of this canal would be reduced so quickly by silt deposition that its use in case of future breaks would be out of the question. Furthermore, to insure the diversion of all the water in the river, required a canal cut considerably below the water-table in the ground through which it would have to pass, and large patches of quicksand occur so frequently in this region that it would be folly to hope to miss all of them. Such patches would cause the inflow of material from the sides and the bottom to a serious extent.

Mr. Rockwood's Plan.—Mr. Rockwood urged the necessity of a rapid re-diversion, not so much because of the effect on the Southern Pacific tracks along the Salton Basin as because he understood the critical condition at a number of points in the irrigation system of Imperial Valley, and that the severe strain could not be withstood successfully for very many months. His suggestion, made in August, 1905, was to put in, immediately beside the break, a wooden **A**-frame, flashboard head-gate, capable of passing the low-water flow of the river; with dredges to dig channels from the break to the gate both above and below; divert the water through this by-pass and gate with a piling-brush-sandbag barrier dam; complete the dam as an earth fill across the break, and build levees both up and down stream as far as might be necessary; then close the gate to such an extent as would admit only enough water to supply the irrigation needs. This plan was approved, and work was started on September 20th. It was abandoned completely 3 weeks later; was again approved on December 15th, 1905; and was carried out until the gate construction failed, in October, 1906. It was daring only in its size and the foundation of so important a structure on alluvial soil, and it would have resulted in permanent diversion works on Mexican soil—where, by all means, they should have been, originally, and as contemplated in the Mexican concession, granted in 1904.

The Barrier Dam Plan.—The Barrier Dam Plan consisted in throwing a barrier dam of some sort across the crevasse and raising the water surface above it sufficiently high to throw all the discharge of the river down the old channel to the Gulf. The usual type of dam was suggested, of piling and brush mattresses of fascines weighted down by sandbags. This method seemed to its proponents to afford opportunity for decreasing the quantity of water diverted in the minimum time, and neglected that side of the problem which required the furnishing of water for the Imperial Valley. The best plan for a structure of this type was that put forward by Mr. Edinger, and worked on under his direction from early in October until its destruction by the great flood of November 29th, 1905.

FIFTH ATTEMPT TO CLOSE THE CREVASSE.

Mr. Rockwood presented his plan to Mr. Randolph and Mr. Schuyler, and they, as well as several engineers of the Southern Pacific Company, approved of its trial. Plans were hurriedly worked out for a wooden

A-frame, flash-board gate, 120 ft. long, with a concrete floor, and founded on piles. Rush orders for materials were placed, and the first shipments left Los Angeles on August 7th. It was fully expected to have the structure completed by November 15th.

The original intention was to construct the gate in a by-pass to be excavated by the dredge *Alpha* on the south side of the intake, but examination showed an unfavorable foundation, as the ground slid into the cut so rapidly that the dredge was almost caught and held by it. The plans, therefore, were changed, and it was decided to construct a by-pass on the other side of the break; force all the water through this by-pass; and then build the structure where the intake had been, thus saving both time and money in the excavation. The break at this point was about 300 ft. wide—just about the length of excavation required for rapid and successful construction. The dredge was put to work on this by-pass, and no difficulty whatever was found in making the 700-ft. cut required. The plan worked very well, and a large part of the water began to go that way at once. Work was begun on the up-stream side of the coffer-dam, the idea being that, when all the water was diverted through the by-pass, another earthen dike would be thrown in, about 250 ft. below the first, and thus make the coffer-dam for the gate construction. In this way, the second dam would be built in still water and in very short order with the dredge.

At this time—about September 15th—it became evident to Mr. Rockwood that he could not attend to the business affairs of the company properly and remain in personal charge of the work along the river. It seemed easier to find some one capable of completing the gate in accordance with the plans outlined than to find any one qualified to handle the corporation's affairs. Mr. Edinger was selected, as he, until June, 1905, had been for many years Superintendent of Bridges of the Southern Pacific System, and had had very large experience in coffer-dam work. About 3 months previously he had left the Southern Pacific Company and entered the contracting firm of Shattuck and Desmond, of Los Angeles and San Francisco. About September 20th, Mr. Edinger and Mr. Rockwood went over the ground and the plans together, and Mr. Edinger commenced the work.

The records show that, about October 1st, the river usually rises 2 or 3 ft., principally due to rains on the water-shed of the Gila River and Bill Williams Fork. This year was no exception, and the slight rise

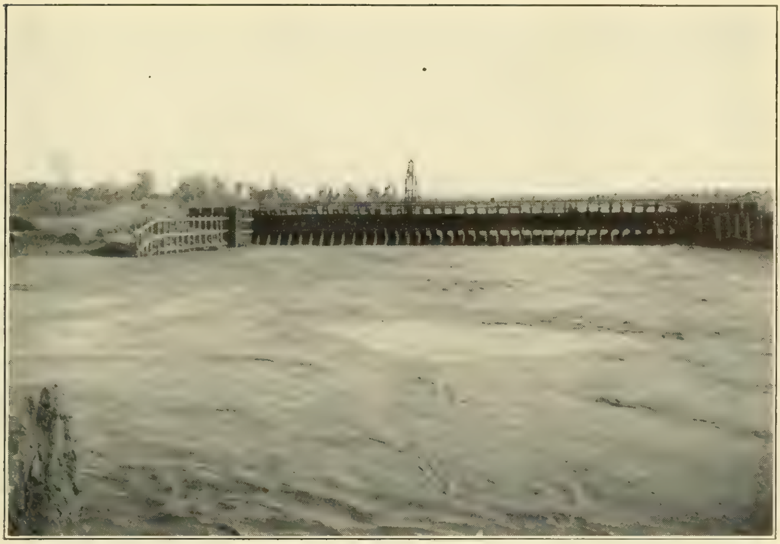


FIG. 1.—ROCKWOOD HEAD-GATE, OCTOBER 6TH, 1906, PASSING 12 000 SECOND-FEET.

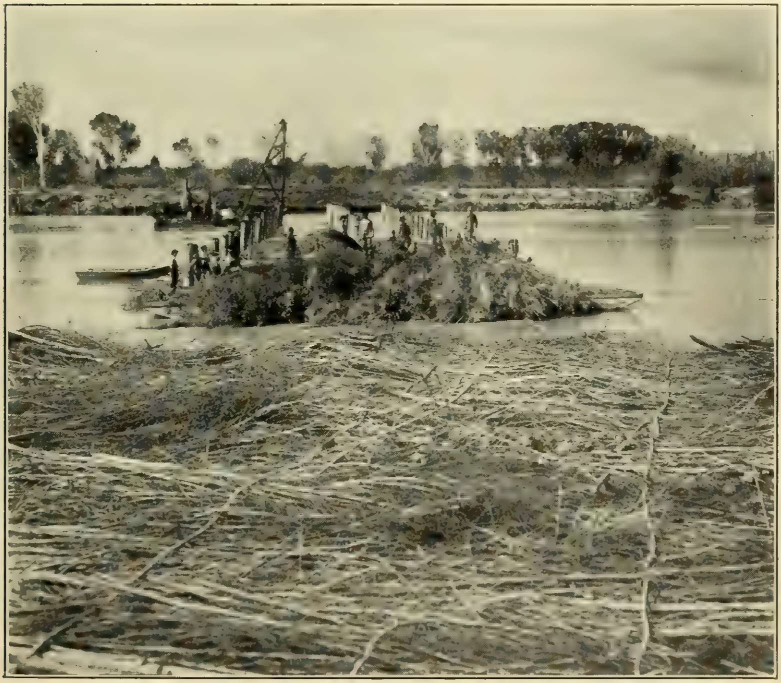


FIG. 2.—EDINGER DAM, NOVEMBER 8TH, 1905. BRUSH AND WIRE MAT IN FOREGROUND, READY TO BE PLACED.

about October 1st shook Mr. Edinger's confidence in the plan. He quickly outlined a barrier dam plan to Mr. Randolph, who approved of it, and work was shifted to it at once. This plan consisted of constructing a piling and brush dam across the west channel between the head of Disaster Island and the Mexican shore, a distance of about 600 ft., and it was expected that the river would all be turned down the east channel before a gate could even be put in. All material was at once removed from the gate site, and work was rushed on the construction of what is locally known as the Edinger Dam.

This plan of handling the situation, in addition to shutting off all water flowing into the Imperial Valley through the lower intake, was seriously defective in that even a short flood sufficiently great to send any water overbank in the immediate vicinity of the dam—and that would require much less water than usual on account of the silted-up condition of the whole river bed below the break—would in a few hours result in cutting the channel around the end of the structure and entirely shunting it. Indeed, such a re-diversion was exactly what took place a little more than a year later, when the waters broke under the levee, ½ mile south of the Hind Dam, in December, 1906. Had the Edinger Dam been entirely successful and completed on November 15th, such re-diversion would have been caused by the terrific flood of November 28th, and so on; the hydrograph, Plate CIX, shows a number of floods sufficiently great to have done this. Indeed, at this time, no one seems to have realized that a large, deep, and efficient channel had been created from the Lower Heading westward for many miles, and that future safety demanded, not only closing the intake, but an elaborate system of levees reaching miles both up and down stream.

The plan of the Edinger Dam consisted in driving rows of piling and filling the interstices with brush mattresses and fascines. The idea behind it was essentially similar to that of the work abandoned about August 1st. To have been successful, the construction would have had to withstand a head of from 8 to 10 ft. However, on November 29th, when a head of 35 in. had been obtained, a terrific flood came down from the Gila, reaching a gauge height of 31.3 ft. at Yuma and a discharge of 115 000 sec-ft. Large quantities of drift were carried by the flood-waters. This drift collected against the Edinger Dam in great quantities, and a large volume of water went down the east side of the island and the old channel. Before the flood had reached its peak, the dam started to give way, and in an incredibly short time was practically destroyed. When the river had again fallen, the old channel was silted up higher than before, the new channel was scoured still deeper, and when the flow of the river had decreased to 17 500 sec-ft. all the water was again going toward the Salton Sea.

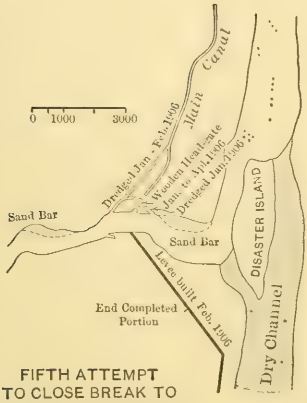
The flood not only wrecked the dam, but carried away practically all the material on the ground, and, after it receded, side-cutting along the west side of Disaster Island began to take it away rapidly. It was soon obvious that it would be folly to resume work at that location, and it was decided that the piling-brush-sandbag barrier dam method was not to be given further consideration.

So much water went through the break to the valley, at the failure of this dam, that the *Alpha* was sent to the Quail River and put to work cutting a channel southward in the hope of diverting a large part of the flow into the Paredones and thence *via* Volcano Lake into the Gulf. It was an endeavor to divert a large part of the water from an old overflow channel on the north side of the delta cone into an overflow channel on the south side thereof. It had little result, however, and the Quail River cut soon closed itself.

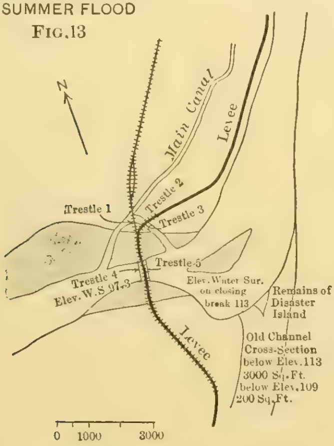
On October 15th there were 20 white men and 25 Indians at work on the Edinger Dam; on November 1st, 42 white men and 50 Indians; on November 10th, 106 white men and 65 Indians, and on November 29th, 250 white men and 80 Indians. Two steamboats with barges attached, and the relatively large barge *Silas J. Lewis,* with their crews, were also at work.

On the books of the company, the cost of the Edinger Dam is not thoroughly segregated from the expense incurred in the head-gate work up to the time of its abandonment for the barrier dam plan. The expenditures on it, however, were about $60 000, and the grand total to December 1st, 1905, was about $100 000.

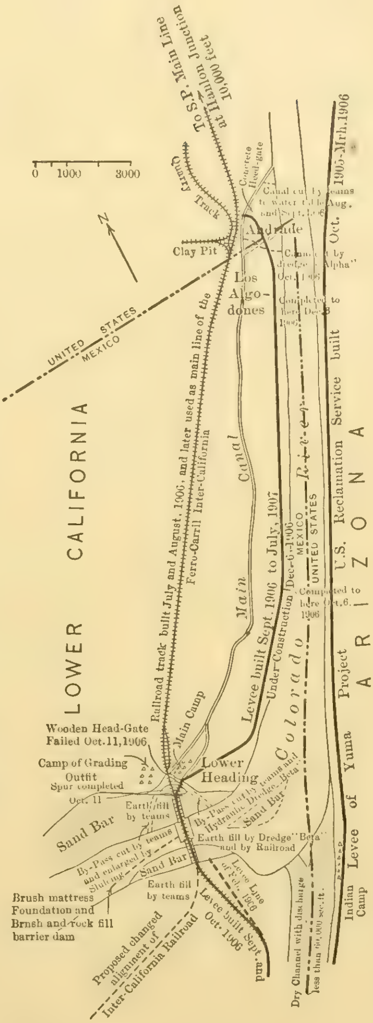
Concrete Head-gate.—The location of this interesting structure is shown on Fig. 14, where the granite point of Pilot Knob is near the right bank of the river. The general design was outlined by Mr. Schuyler, and the principles used, dimensions, elevations of flow, etc., were submitted to Messrs. Rockwood and Randolph, and approved by them. George S. Binckley, M. Am. Soc. C. E., then worked out the details and prepared the working drawings. Contracts for the structural steel and ironwork were let to the Llewellyn Iron Works, of Los



FIFTH ATTEMPT
TO CLOSE BREAK TO
APRIL 15, 1906-BEGINING
OF SUMMER FLOOD
FIG. 13


N
Main Canal
Levee
Trestle 1
Trestle 2
Trestle 3
Trestle 4
Trestle 5
Elev. W.S. 97.3
Elev. Water Sur. on closing break 113
Remains of Disaster Island
Levee
Old Channel Cross-Section below Elev. 113 3000 Sq. Ft. below Elev. 109 200 Sq. Ft.
0 1000 3000

SIXTH AND SUCCESSFUL
ATTEMPT TO CLOSE THE BREAK
OCT. 12 TO NOV. 4, 1906
FIG. 15


To S.P. Main Line at Hanlon Junction 10,000 feet
Quarry Track
Concrete Head-gate
Canal cut by teams to water table Aug. and Sept. 1906
Andrade
Clay Pit
Canal cut by dredge "Alpha" Oct. 1906
Los Algo-dones
Completed to here Dec. 3 1906
0 1000 3000
N
UNITED STATES
MEXICO
LOWER CALIFORNIA
Railroad track built July and August, 1906, and later used as main line of the Inter-California Ferro-Carril
Main Canal
Levee built Sept. 1906 to July, 1907
Under Construction Dec. 6, 1906
Colorado River
MEXICO
UNITED STATES
Completed to here Oct. 6, 1906
U.S. Reclamation Service Project built Oct. 1905-Mrh. 1906
ARIZONA
Levee of Yuma
Indian Camp
Wooden Head-Gate Failed Oct. 11, 1906
Main Camp
Camp of Grading Outfit
Spur completed Oct. 11
Lower Heading
Earth fill by teams
Sand Bar
By-Pass cut by teams and Hydraulic Dredge "Beta"
Sand Bar
Earth fill by Dredge "Beta" and by Railroad
By-Pass cut by teams and enlarged by Sluicing
Sand Bar
Earth fill by teams
Levee Line of Feb. 1906
Levee built Sept. and Oct. 1906
Brush mattress Foundation and Brush and rock fill barrier dam
Proposed changed alignment of Inter-California Railroad
Dry Channel with discharge less than 60,000 sec. ft.

FIFTH ATTEMPT TO CLOSE THE BREAK-
JULY 1, TO OCT. 11, 1906
AFTER SUMMER FLOOD
FIG. 14

Angeles, and for the construction work to Mr. Carl Leonardt, also of Los Angeles, on November 25th, 1905. Time was made the essence of the contract, and Mr. Leonardt hurried the necessary equipment to the ground and began actual work 2 weeks later. Although it was expected to complete the gate ready for use within 90 days, the entire job was not finished until June 28th, 1906.

Type and Size.—The intake gate is doubtless the largest and most expensive irrigation canal head-gate in America. The design is a modification of the Taintor or radial-gate type, which has been used for many years for irrigation constructions in the Western States. This style of structure was adopted in order to obtain openings of maximum area easily and quickly opened or closed by one man. It had probably not been used in Calfornia, although a large wooden radial-gate had been built some years before at the head of the so-called Peoria Canal from the Gila River, near Gila Bend, Ariz. It was about 25 ft. high and 30 ft. wide, which is nearing the extreme for construction of that class. This wooden gate, however, was never used, as the dam across the Gila River was destroyed by flood soon after its completion. The maximum height of radial-gates and canal head-works in Idaho at the time was about 11 ft., and the water was not expected to rise to the top of the gates, the river level being controlled by other means.

Here, however, the extreme flood level is 19 ft. higher than the low-water level, so that gates at high flood time are subjected to great pressure. Sufficiently large vertical lifting gates would have required very heavy and massive piers, and the gate would have been very large and disproportionately high as compared with the width. These considerations caused the adoption of culvert openings between the piers for supporting a cellular structure of reinforced concrete, and thus admitting of loading the construction with gravel filling in the cells in order to get the required stability and weight at minimum cost. The gates were thus required to close culvert openings of minimum size, being in fact no larger than with the head at a uniform low-water height, although, of course, much heavier and stronger on account of the increased pressure at flood stages. There are eleven such culverts, each 10 ft. high and 12 ft. wide. In addition, there is a "navigation pass," the purpose of which was to permit passing a small gasoline launch through the gate. This navigation pass is practically useless because the mill race through it, when the difference in water level above and below the gate exceeds 1 ft., precludes the idea of dragging a boat through it; indeed, no attempt has ever been made to use it. The floor of the gate is 98 ft. above sea level, according to the C. D. Co. datum, and 100.9 ft. according to the U. S. Reclamation Service datum. At the time, and until after the summer flood of 1909, the average low-water surface in the river was about 108 ft. The elevation of the flow line at the gate, therefore, was fixed so that the culverts would run full at low-water stage. The present low-water surface is about 105 ft.

The area of the eleven culverts in 1 320 sq. ft., and, with the water 1 ft. higher on the up-stream than on the down-stream side of the gate, their combined discharge would be 8 500 sec-ft. In addition, a large quantity of water would go through the navigation pass, which is 10 ft. 3 in. wide. When the water is 10 ft. above the top of the culverts, it is necessary to close the gates within 3.8 ft. of the bottom to hold the discharge through them down to 10 000 sec-ft., when the carrying capacity of the canal below is great enough to allow the water to get away.

The gate was designed to pass the entire low-water flow of the river—which it was assumed would certainly not exceed 10 000 sec-ft.—without any diverting dam in the river opposite it.

Cost of Structure.—Table 12 gives the cost of this structure, with the contract prices for excavation, concrete work, etc.

The cost of the gate, however, was considerably more, because Contractor Leonardt presented a claim insisting that the prices for earth and rock excavation named in his contract were agreed to by him on certain assurances made by Mr. Rockwood as to the character of the excavation which proved more difficult than expected. This claim was made as soon as Mr. Leonardt's representatives reached the ground, and Mr. Randolph permitted a change to a force account basis because of his desire to hurry the construction in every possible way. The earth excavation in this way cost 64 cents per cu. yd. and the rock $2.06, thus increasing the figures by $10 813, making a grand total of $55 221.08.

Careful accounts were kept, and it was ascertained that the contractor made a profit of $2 700 on the concrete, and $741.50 on erecting the gates. What the earth and rock excavation should have cost is a matter of some, though slight, interest to the Profession, as these would necessarily vary according to local conditions. As a matter of fact, with a good pumping plant, a mining nozzle or giant, a hydraulic elevator, and some pipe, the earth excavation could probably have been handled for 20 cents per cu. yd., and possibly less. Much of the rock was fairly soft, and could have been worked easily and cheaply, so that, had the contractor put in power drills and one or two long-boom derricks to handle the rock out of the cut, it is probable that the cost of such excavation would not have exceeded the contract price. The quantity of water entering the coffer-dam, or rather excavation pit, was surprisingly small.

TABLE 12.

Gate Structure.	
Earth excavation, 12 637.1 cu. yd. at $0.25	$3 159.28
Rock excavation, 5 700.81 cu. yd. at $1.00	5 700.81
Cement, furnished by company, 1 335 bbl. (Olsen, Gillingham, and Independence brands)	4 432.25
Concrete, labor, forms, sand, gravel, and rock, 1 204.83 cu. yd. at $9.00	10 843.47
Reinforcing steel bars, 25 722 lb. at 4 cents	1 965.16
Expanded metal for gate facings, 791 lb. at 4 cents	31.64
Allowance for 3 days' delay to contractor	102.50
Extras	807.07
	$27 042.18
Charges against contractor	271.70
Total cost of gate structure	$26 770.48
Iron and Steel Work for Gate.	
Llewellyn Iron Works' original contract for twelve radial gates and one slide-gate (in navigation pass) f. o. b. Los Angeles	$12 000.00
Freight to Yuma, on 212 184 lb. metal in aforesaid gates at $1.25 per ton	132.60
Regulating levers, shaft, and gear (subsequent contract)	580.00
Erection of gates (Leonardt's contract)	1 500.00
Total cost of iron and steel work	$14 812.60
Plans, engineering, and superintendence, 6.7%	2 825.00
Total cost of head-works	$44 408.08

Fig. 10 gives a plan and elevation of this gate, and Figs. 1 and 2, Plate CXI, are views of the structure.

Purpose.—At the time this gate was designed, the money available for construction, through the Southern Pacific's connection and the loan of $200 000, justified the immediate construction of permanent

PLATE CXI.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.

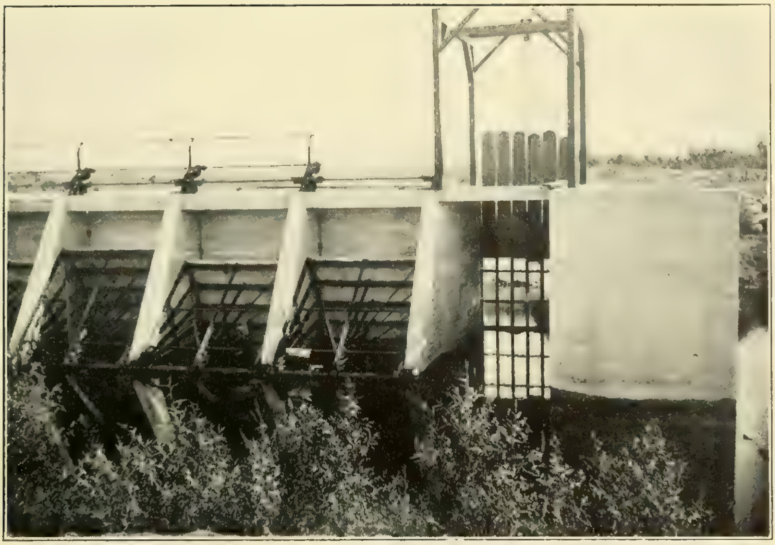


FIG. 1.—CONCRETE HEAD-GATE, JULY 10TH, 1906, SHOWING DETAILS OF GATES, NAVIGATION PASS, AND GATE AND ABUTMENT AT RIVER END.

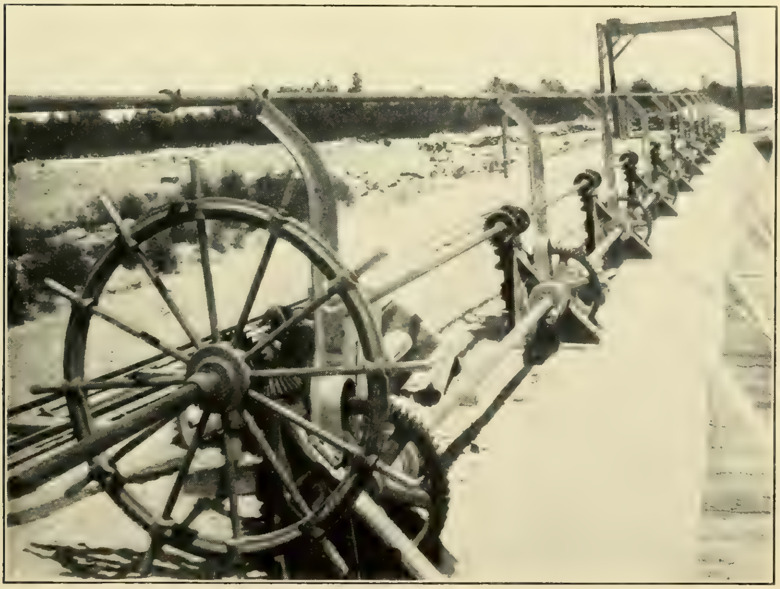


FIG. 2.—GATE RAISING MECHANISM OF CONCRETE HEAD-GATE.

head-works, indeed, building this and the Alamo Waste-gate were the chief items for which the loan was made. Furthermore, the entire diversion of the river at the lower intake had shown the folly of trying to get along without them. The gate, while intended as a permanent diverting structure, was, nevertheless, primarily designed for use in endeavoring to re-divert the river; otherwise, of course, it would have been made much less than half as large. Actually, it played no part at any time in diverting the stream.

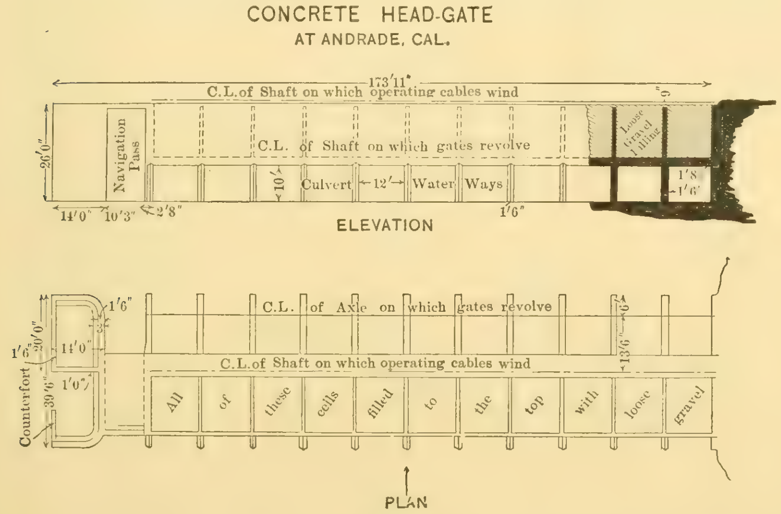

CONCRETE HEAD-GATE
AT ANDRADE, CAL.
173′11″
C.L. of Shaft on which operating cables wind
26′0″
Navigation Pass
C.L. of Shaft on which gates revolve
Loose Gravel Filling
10′
Culvert
12′
Water Ways
1′8
1′6″
14′0″
10′3″
2′8″
1′6″
ELEVATION
1′6″
C.L. of Axle on which gates revolve
20′0″
14′0″
1′6″
3′
C.L. of Shaft on which operating cables wind
13′6″
1′0″
39′6″
Counterfort
All of these cells filled to the top with loose gravel
PLAN

FIG. 16.

Operation.—The gate was actually put into operation on November 1st, 1906, when the water going through the break had been reduced to a quantity too small for the requirements of the valley. About 6 weeks later, the flood which caused the second break occurred, and resulted in an accumulation of drift on the up-stream side of the gate which choked up the underground culverts and practically put it out of commission. From that date to this the troubles caused by drift in the river, particularly at high-water periods, have been serious and often acute. Gates of this type, for head-works on a river carrying any drift to speak of, let alone as much as the Colorado often has, should be avoided. After considerable experience it is obvious that if permanent diversion of the water for the irrigation of the valley is not made on Mexican territory, then, whenever enough money is available, it will be best to abandon the structure entirely and make diversion through gates similar to those in the sluice-ways of the Laguna Weir.

Aside from the type of gate for such a locality and stream, three unfortunate features in design became manifest. Chief of these was the fault that the drums on which the wire cables for raising the gates are wound are much too small. The gates themselves were designed for minimum weight with the necessary strength, and are not stiff enough, so that they tend to wedge unless exceedingly great care is taken. The net result is many broken cables. At one time only two of the eleven gates were in operation, some being clear down, some clear up, and some impossible to close entirely on account of driftwood under them. Fortunately, the *Delta* was near by and was used to raise the gates, so that new and strong plow-steel cables could be installed, replacing the original ones of Tobin bronze, ¾ in. in diameter, 19 wires to the strand. These plain steel cables corrode badly, of course, but still are much better than any galvanized iron ones of usable diameter.

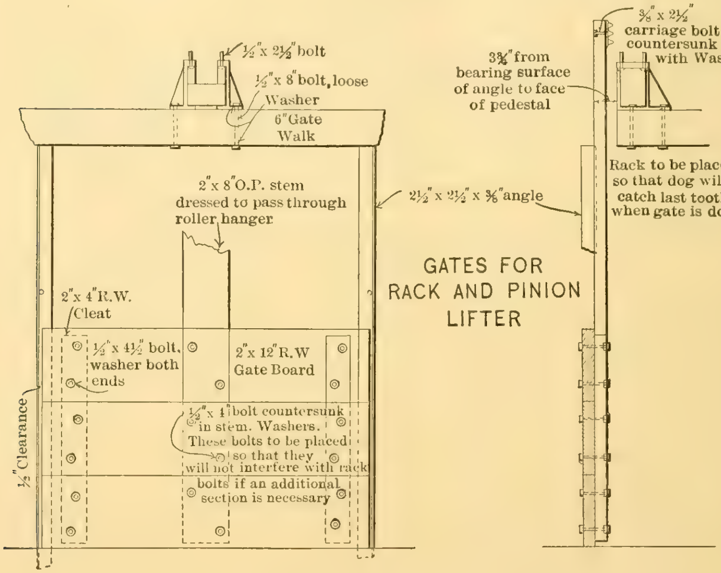

½"x 2½" bolt
½"x 8" bolt, loose
Washer
6" Gate Walk
2"x 8" O.P. stem dressed to pass through roller hanger
2"x 4" R.W. Cleat
½"x 4½" bolt, washer both ends
2"x 12" R.W Gate Board
½"x 4" bolt countersunk in stem. Washers. These bolts to be placed so that they will not interfere with rack bolts if an additional section is necessary
½" Clearance
2½" x 2½" x ⅜" angle
3⅜" from bearing surface of angle to face of pedestal
⅜" x 2½" carriage bolt countersunk with Washer
Rack to be placed so that dog will catch last tooth when gate is down
GATES FOR RACK AND PINION LIFTER

FIG. 17.

Another bad feature of the design is the form of abutment built on the outer end of the gate. The writer has always been fearful that water would find its way through the 10-ft. tongue of puddled earth which is the only barrier preventing water from getting around the end and shunting the gate entirely.

In September, 1906, a canal, from the river to the head-gate, was excavated by teams and Fresno scrapers. This intake was made 100 ft. wide at the bottom, with 2½ to 1 side slopes down as low as the underground water-table would permit. At about the same time the *Alpha* reached the Upper Heading and cut into the concrete gate excavation from the Main Canal below. The upper connection was wide enough, but the bottom was at least 6 ft. above the floor of the head-gate, and the down-stream connection was about 3 ft. above the floor of the gate and much narrower. These connections were widened and deepened to their present capacity by erosion, dredging, and blasting, as explained later.

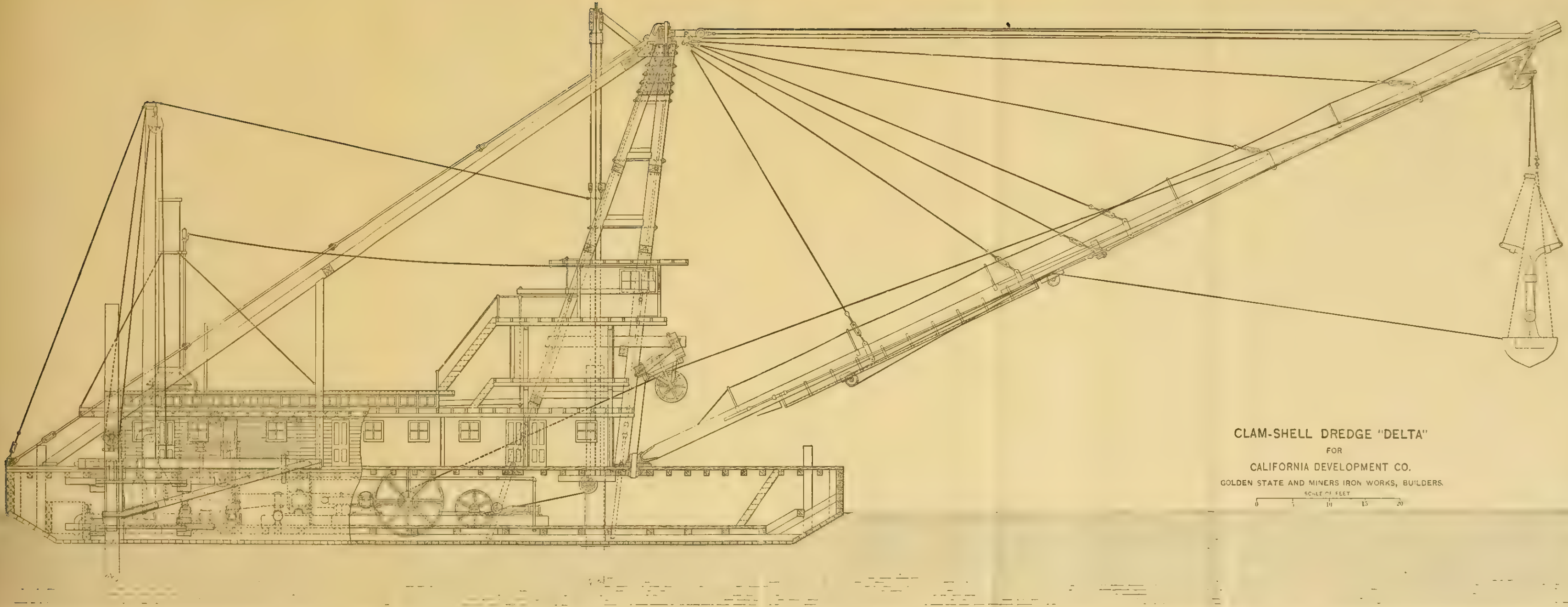
The Dredge, Delta.—The other element in the concrete head-gate plan of re-diversion was a canal from the head-gate to the break, a distance of approximately 4 miles. It was to be of sufficient size to carry the probable minimum flow of the river, 10 000 sec-ft. As it was obvious that this stretch of canal would have to be lower than the bed of the river all along the line, in order to permit of taking the entire low-water flow without a diversion dam in the river opposite the head-gate, a very large part of the cross-section to be excavated would be below the permanent water-table of the region. Therefore, some kind of excavating machinery which could handle large quantities of material under water had to be provided. It was taken for granted that the cheapest and quickest method of providing this waterway was to enlarge the existing Main Canal, although the writer thinks this was erroneous. The dipper dredge, *Alpha,* by almost continuous operation in this part of the course, had built up levees on both banks so high as practically to limit its future operation without flattening down these levees with teams and scrapers. Largely on the advice of Mr. Edinger, it was decided to construct a clam-shell dredge of the type used almost exclusively for levee building along the Sacramento River. Accordingly, a contract for machinery, and for plans, bills of materials, etc., of the hull, was entered into with the Golden State and Miners Iron Works, of San Francisco, which makes a specialty of clam-shell dredge machinery, construction, and even operation, on the Pacific Coast. This contract was closed on January 10th, 1906. The

320 000 ft. of Oregon pine lumber and other materials for the hull were bought through the purchasing department of the Southern Pacific Company, and the unusually large timbers required were obtained in Oregon and sent directly to Yuma. In the purchase of both hull material and machinery, time was considered as of the essence of the contracts.

A dredge with a 150-ft. boom, carrying a 5-cu. yd. bucket was decided on, and a hull 120 ft. long, 54 ft. wide, and 11 ft. deep. This width was 2 ft. greater than had ever been built on the Coast, although the tendency is to increase the dimensions, and one is now building in San Francisco, 70 by 140-ft. hull, 205-ft. boom, and 6-cu. yd. bucket. The machinery is a 150-h.p., internally-fired, circular, fire-tube boiler, and a 20 by 24-in. engine on each side. It was decided to build the hull and erect the machinery at Yuma, and float the completed dredge down the river to the intake.

Lumber for the hull began arriving in Yuma late in January, and early in March the company was notified that all the machinery was ready at San Francisco for shipment. Mr. Edinger's connection with the company had ceased soon after the destruction of the Edinger Dam, and Mr. Rockwood had very little confidence in the feasibility of the concrete head-gate plan, or in the desirability or need for the clam-shell dredge, and felt that the great cost thereof would deplete seriously the $200 000 loaned by the Southern Pacific Company. Therefore, practically nothing was done in the matter, and so it came about that the great conflagration in San Francisco, following the earthquake of April 18th, 1906, destroyed the plant of the Golden State and Miners Iron Works, in which all the machinery for this dredge was stored ready for shipment. Fortunately, the damage sustained by the apparatus was not extensive, and by May 15th, 1906, all the machinery had reached Yuma.

Mr. J. W. Brown, a member of the Golden State and Miners Iron Works Corporation, agreed to take charge of building the hull, and reached Yuma about May 1st, bringing with him a complete crew of mechanics and ship builders. Work was hurried, and with such success that the hull was launched about August 15th, the machinery was in place by the end of October, and the dredge weighed anchor and started down the river. At this time the river was getting low and some difficulty was encountered, but on November 26th, 1906, the



CLAM-SHELL DREDGE "DELTA"

FOR

CALIFORNIA DEVELOPMENT CO.

GOLDEN STATE AND MINERS IRON WORKS, BUILDERS.

clam-shell arrived at the mouth of the American intake. The total cost of the dredge, ready to start down the river, was almost $80 000, the cost of the machinery being $34 000, f. o. b. San Francisco. The weight of the craft is about 850 tons.

This dredge, Plate CXII, has been an invaluable piece of machinery to the C. D. Co. Had it been ready for use in August, 1905, the cost of doing the earthwork in the Hind Dam would have been wonderfully reduced. As it was, the dredge, after doing a little work in enlarging the intake above the concrete head-gate, was floated down and cut its way into the Main Canal following the upper Mexican intake. It was engaged on this work when the second break occurred, and continued thereon as though this latter event had not happened. Like the concrete head-gate, it played no part whatsoever in the rediversion of the river.

For the information of those who are not familiar with the results and cost of clam-shell dredge operation, the following data are given:

Operatives.

1 Captain	at	$125 to $150	per	month,	and	board.
3 Levermen	“	85	“	“	“	“
2 Firemen	“	60	“	“	“	“
2 Deckhands	“	50	“	“	“	“
1 Cook	“	50	“	“	“	“
1 Blacksmith	“	90	“	“	“	“
1 Roustabout	“	40	“	“	“	“

Three shifts give a total of 22 hours actual work daily. The average time in operation, when proper repair work is done, is 28 days per month. When in good ground, and with side swings averaging 70° on each side, the time per bucketful is 40 sec. The quantity handled (varying according to the material) is from 3 to 8 cu. yd. as ordinary extremes. On the Sacramento River, under good conditions, 150 000 cu. yd. per month are handled.

Monthly expense.

Maintenance and operation	$2 500
Interest on investment at 6%	400
Taxes and insurance	200
Deterioration	700
Sometimes as low as	$3 800

Ordinarily, the monthly expense in Mexico is $5 000. The average cost is 2¾ cents per cu. yd. The average cost of the work done by the *Delta* in Mexico is from 4 to 6 cents per cu. yd.

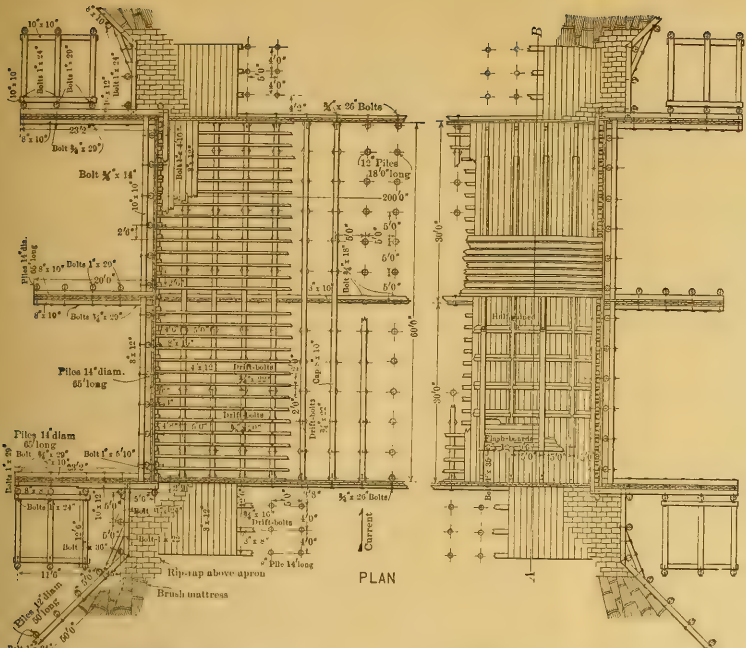
THE ROCKWOOD HEAD-GATE.

As already explained, it was decided to follow both Mr. Schuyler's and Mr. Rockwood's plans for diverting the river, and so, for the second time, on December 15th, 1905, Mr. Rockwood was authorized to proceed with the construction of a wooden head-gate beside the lower intake. The heavy flood of November 29th and its receding waters had widened the intake from 300 to approximately 600 ft., and, after considering the conditions, it was decided to build the gate directly in the old canal about 200 ft. north of the intake channel, in order to reduce the time and the quantity of excavation required, and to divert the relatively small quantity of water in the old canal around the gate with a by-pass to be dug by the *Alpha*. The gate, started and abandoned three months before, was originally planned for a width of 80 ft.; this was increased to 120 ft. in order to carry a maximum of 9 000 sec-ft. As the gate could not be completed until the spring of 1906, the length was extended to 200 ft. The over-all dimensions, including the wooden aprons, became 240 by 100 ft. The entire space, of course, had to be inclosed in a coffer-dam and the excavation made inside of it. The plans are shown on Plate CXIII.

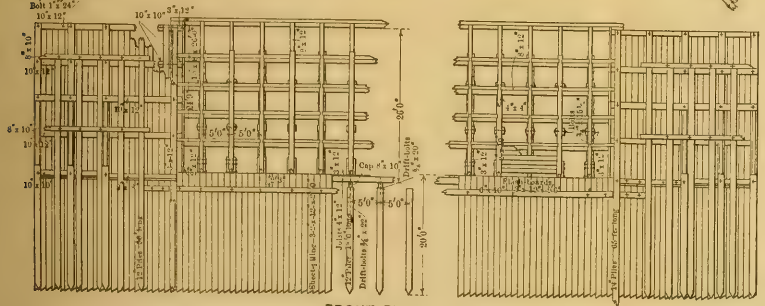
As far as the writer has ever heard, this is the largest and most daring design ever made for a wooden **A**-frame, flash-board head-gate. Pile-driving was begun on January 7th, and the gate was completed on April 18th, 1906; the work was rushed day and night for the greater part of the time, and no real difficulties whatever were encountered. As in the case of the concrete head-gate, 4 miles above, the quantity of water seeping into the excavation was surprisingly small. The various items of the cost of this structure were not segregated, so that the details cannot be given, but the grand total expense of the gate proper, exclusive of the by-pass, was approximately $122 500.

The discharge of the river by April 10th, was 32 200 sec-ft., and showed that the annual flood had begun, therefore all idea of attempting to divert the water through the gate by damming the crevasse itself before the summer flood should have been passed, was abandoned.

PLATE CXIII.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.

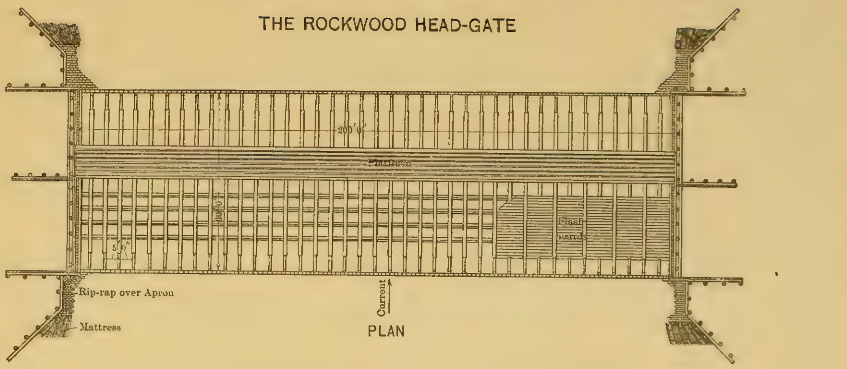


PLAN



FRONT ELEVATION

THE ROCKWOOD HEAD-GATE



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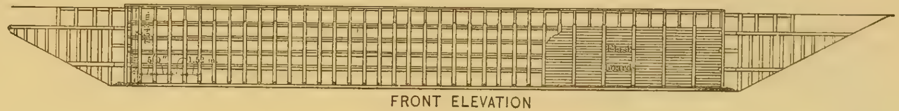
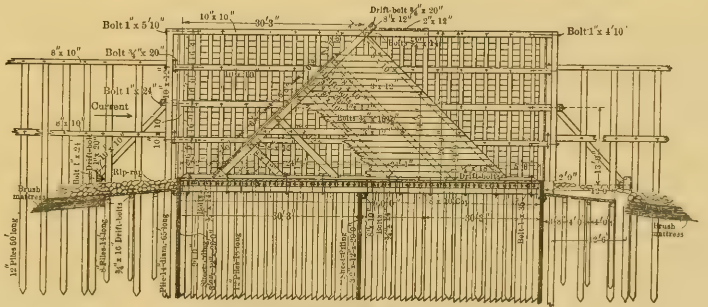


FRONT ELEVATION



SECTION ON A-B

Change in Engineering Staff.—On May 15th, 1905, the writer was transferred from the Southern Pacific Company in San Francisco to the Associated Harriman Lines in Arizona, with the title of Assistant to the President of those properties. About 5 weeks later Mr. Randolph's duties were increased by being put in charge of the C. D. Co. and the Mexican Co., and shortly thereafter the officials of the Southern District of the Southern Pacific Company urged on him the very serious fact that the track beside the Salton Sea would soon be under water, and insisted that aggressive action be taken to close the break on the river. About the middle of July Mr. Randolph sent the writer to the river to confer with Mr. Rockwood, and a day was spent together examining the situation. About August 1st a second trip was made, and after the disastrous flood of November 28th, 1905, a third visit. Toward the end of January Mr. Randolph again sent the writer to the Lower Heading to assist Mr. Rockwood in hurrying the construction of the wooden head-gate. As this work neared completion, Mr. Rockwood suggested that he had found it impossible to handle things in accordance with his own ideas; he believed that the best interests of all concerned pointed to his resignation, and urged that the writer take up the work. After considerable discussion it was agreed that, if Mr. Randolph also desired the arrangement, there would be no objection offered. Shortly afterward these gentlemen met in Los Angeles and agreed to the change, and on April 19th, Mr. Rockwood resigned as Assistant General Manager and Chief Engineer, and was appointed Consulting Engineer, and the writer was appointed General Manager and Chief Engineer. Mr. Rockwood continued to act as Consulting Engineer until October 1st, 1906, when he severed his official connection with the company.

The San Francisco Fire.—On April 18th had occurred the earthquake which resulted in the great San Francisco conflagration, and exaggerated rumors as to the extent of the disaster made it seem certain that the machinery for the *Delta* was utterly destroyed; but that was the least important result, as far as the C. D. Co. was concerned. It appeared that the key city to the Harriman Lines was practically in ruins, and the Southern Pacific Company, as a railroad organization, was very seriously hurt.

Mr. Randolph hurried to San Francisco to join with the other officials in the West in conferring with Mr. Harriman, who had at once started for the scene. There, in the bustle and confusion of temporary offices, with the ruins of San Francisco still smoking, with the facilities of the road to carry people away from the stricken city taxed to the very utmost, with the wonderful railway system which constituted Mr. Harriman's life work crippled to an unknown extent, and with the financial demands resulting from the disaster impossible to determine, Mr. Randolph succeeded in inducing Mr. Harriman to advance an additional $250 000 for controlling the Colorado River and protecting Imperial Valley. It has always seemed to the writer that this was really the most remarkable thing in the whole chain of extraordinary happenings.

The Situation.—The wooden head-gate was completed, and the upper and lower by-passes connecting it with the break had been fairly well started with the dredges, *Alpha* and *Beta;* the concrete head-gate was well under way; the material for the hull of the *Delta* was in Yuma, and the machinery seriously damaged in San Francisco; the tracks of the Southern Pacific Railroad along the Salton Basin were nearly awash for a considerable length; the annual summer flood of 1906 had begun, and, from the Weather Bureau reports from the drainage basin, would be a very large one; the irrigation system of Imperial Valley was already threatened at several vital points by the excessive quantity of water going down the Alamo channel or Main Canal; and friction between the old C. D. Co. stockholders and the new management had commenced.

No very great degree of reliance could be placed on the wooden head-gate, considering the character of its foundations; and the failure or serious weakness of that structure meant the failure and abandonment of the Rockwood plan for re-diversion. The difficulties of the Concrete Gate Plan, under the most favorable circumstances, became more apparent with further investigation, and were very greatly accentuated by the delay in getting the *Delta* into commission. The probability of the withdrawal of financial support at any time through the discouragement of the Southern Pacific officials as to the ultimate success of the work was a serious factor. Transportation facilities from Yuma were very inadequate, consisting of the steamers, *Searchlight, St. Vallier, Cochan,* and the barge, *Silas J. Lewis,* all of sufficiently light draft to navigate through the shoals and sand bars of the Colorado. There were large quantities of willow brush suitable for fascines and mattress work near the break, but no timber suitable for piling. The nearest point where piles and heavy timber were obtainable was Los Angeles; from there they came by rail to Yuma, from which point they could be floated down the river only at considerable risk, so that it was cheaper to load them on barges and bring them down with steamboats.

Experience thus far had indicated the practical impossibility of closing the break with a piling-brush-sand bag barrier dam, and there were no quarries for many miles either west or east along the railroad, and none, of course, available except with railroad facilities for loading and transportation. Further, rock would require to be transferred to barges at Yuma and be brought thence by river to the scene of operations.

Practically every engineer—and they included many of established national and international reputation—who had visited the break considered a rock fill barrier dam as entirely unworthy of consideration, for two reasons:

First, it was believed that rock would sink into the soft alluvial silt bottom and keep on going down indefinitely, even if more and more slowly. Old river men quoted numerous instances of wrecked river craft. They cited a dredge, bought a few years before by the C. D. Co., which had sunk on its way from Yuma to the upper intake, gradually settling entirely out of sight in a few months. The consensus of opinion, therefore, was that any rock fill would certainly settle out of sight unless built on a very strong brush mattress foundation, and the probabilities were great that such a mattress would break under the load and fail of its purpose.

The second vital objection urged against a rock fill barrier dam was that the water going over it while building would dislodge some portion of the fill or some one rock at the top, thereby increasing the overpour at this point, which would dislodge more rock and in this way quickly result in a breach which could not be closed.

It was thought that these considerations not only quite precluded the idea of a barrier dam, should the wooden gate fail, but rendered very doubtful the construction of a diversion dam or obstruction in the channel opposite the gate which would cause a difference in head, above and below it, great enough to throw all the water through the by-pass and gate. This head was variously estimated at from 3 to 6 ft.

—the head on the finished dam would be about 15 ft. at low-water stage.

On one point there seemed to be accord, namely, that the situation was a desperate one and without engineering parallel, and that there seemed to be little more than a fighting chance of controlling the river. No two of the nearly fifty eminent engineers, who visited the scene and examined into the situation more or less carefully, agreed on any one plan as offering the greatest chances of success, but pointed out fundamental weaknesses in practically all other methods suggested. This feature was so marked that when the writer suggested to President Randolph that the immensity of the interests dependent for their safety on the re-diversion of the river seemed to render advisable a Board of Engineers, he answered that he would regard 100 ft. of good strong brush mattress in place on the river's bottom as more valuable than the report of any Board of Engineers which could be gotten together.

The immediate menace, however, was from the summer flood in passing through the Imperial Valley to the Salton Sea. The Weather Bureau's reports from the upper drainage basin then indicated a very great total discharge, and a peak perhaps as high as 100 000 sec-ft. The crevasse had now enlarged, and the old channel below had filled up, so that practically all this water—several times as much as had ever yet entered the valley—must go the new way.

Summer Flood of 1906.—Plate CIX shows that, compared with recent floods, the summer flood of 1906 was very large, although it has been greatly exceeded since then, notably in 1907 and 1909. The increased fall down the Alamo River channel resulted by August 1st in lowering the river at the diversion point approximately 4 ft., but it silted up as the flood receded, leaving a net lowering of between 2 and 3 ft. (Fig. 3.)

It widened the break from 600 to almost 2 700 ft., and rendered far more expensive, in time, equipment, and money, the task of putting the wooden head-gate into commission. The most important effect, however, was the danger it caused in various ways in the Imperial Valley proper.

Such a vast quantity of water going down the Alamo channel was, of course, never contemplated in designing the new waste-gates near Sharp's Heading discharging down the Alamo River (built June to

August, 1905), and at Station 134 on the Central Main, and they were taxed to their absolute limits. So much passed the Alamo Waste-gate that it caused a recession of the grade in that channel below, so that the structure was, figuratively speaking, on stilts. Twice the chute below the structure had been extended, the last time in February and March, 1906, when the equipment was removed just as the water began to go over the top of the gates.

By a peculiar and most fortunate coincidence, when the Alamo Waste-gate was discharging approximately 3 500 sec-ft. and Sharp's and the Encina Head-gates were being utilized to the capacity of the canals below them, the water in the Alamo above this point spread overbank for miles, going to the west and south sufficiently deep to save the situation. Thus it happened that when the peak of the flood was reached, and approximately 75 000 sec-ft. were going down the Alamo channel toward the Salton Sea, all but about 5 000 sec-ft. were going overbank to the south and west. Had not this most fortunate condition existed, the Imperial Valley irrigation system would early have been broken into the deep channel of the Alamo below the waste-gate, and at once cut the water out of every canal.

Most of this overbank flow to the south and west collected in the various sloughs and low lands, particularly Beltran's and Garza's Sloughs, and flowed into the New River. The small channel of this watercourse was overtopped, of course, and the water spread out, just south of the Boundary Line near Calexico, for a maximum width of about 10 miles. Some of the water overtopped the divide of the delta cone, gained the Paredones channel, and thence ultimately reached the Gulf.

The most critical points were where the New River channel crossed the Boundary Line, and a little farther down along the Central Main. At Calexico and Mexicali this broad sheet of water rose until it covered the ground about 4 ft. in depth. (Figs. 2 and 3, Plate CXIV.) The danger was not appreciated in time to throw levees to the west of the railroad track and thus protect that property. The disposition of the towns and the railroads was to wait for the C. D. Co. to build protective levees, in spite of that company's announced intention of doing nothing of the sort.* When the situation was finally realized, about 5 miles of levee—maximum height 5 ft.—encircling the two towns and connecting at the north and east with higher ground, was hurriedly built. Strong winds blow in the spring for two and three days at a time, and when such storms swept over a wide stretch, even though the ground had a considerable quantity of brush, waves were caused which made the maintenance of these levees at times very critical. They were held successfully, however, until the recession of the New River grade made them no longer necessary.

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* This was because the company's attorney advised that it was not responsible legally for damages caused in the United States by operations of the Mexican Company in Mexico, and to avoid carefully any action which might be considered as an admission of responsibility by the company.

Along the Central Main, from near the branch railroad crossing west to beyond the "Five Gates" (where the canal turns to the north), the water rose so high during the last days of February that it overtopped the south bank of the canal, and only by the most desperate work was it prevented from overtopping the north bank and sending water northeastward across the country to the Mesquite Lake Basin and the Alamo channel. Had this occurred, the Town of Imperial would have been most seriously threatened, perhaps destroyed, and the New River and Alamo chasms would have been joined by a third one, about 25 miles long, diagonally across the valley northeast and southwest. The C. D. Co. then greatly strengthened this north bank and raised it 4 ft. for a distance of nearly 3 miles. When the situation was most threatening the citizens of Calexico and Mexicali were called out to help hold the levees, while the people of Imperial rushed down to aid in the fight along the Central Main.

Both the Alamo and New River channels cut back, owing to the large quantity of water flowing in them, and the Salton Sea began to rise at the rate of approximately 7 in. per day. The Southern Pacific main line there was being shifted from time to time, by means of "shooflies." Along the branch line from Imperial Junction to Calexico the trouble at the crossing of the Alamo channel was far greater than should have been permitted. At no time was more than 3 500 sec-ft. going down the Alamo, yet this small quantity was permitted to eat away approximately 300 acres of land, in a semi-circular form, from the right bank of the channel where it is crossed by the branch railroad into the valley, and caused the railroad to "shoofly" its tracks five times. The alluvial soil of the Imperial Valley is very easily eroded, especially on the concave side of river bends, but it should have been possible to control at reasonable cost a stream of 3 500 sec-ft., with a velocity never exceeding 7 ft. per sec.

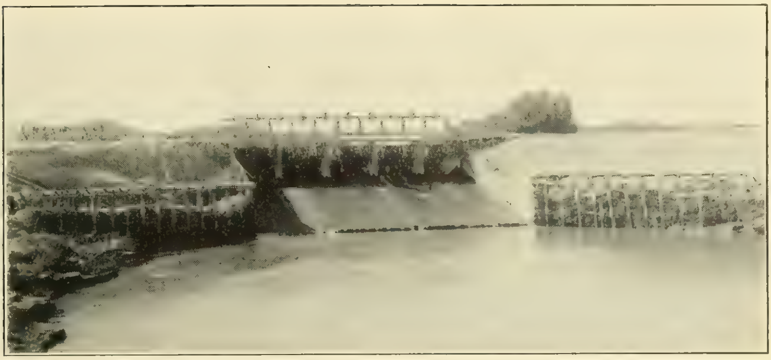

Fig. 1.—Alamo Waste-Gate, November 17th, 1906. About 30 Feet Head Against Gate.

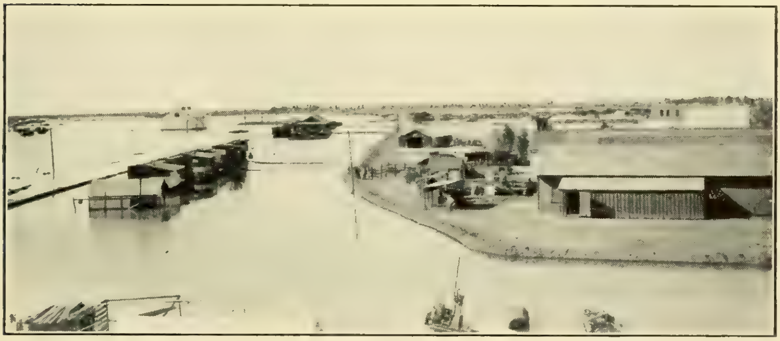

Fig. 2.—Portion of 4-Mile Levee Protecting Calexico and Mexicali, in Flood of June, 1906.

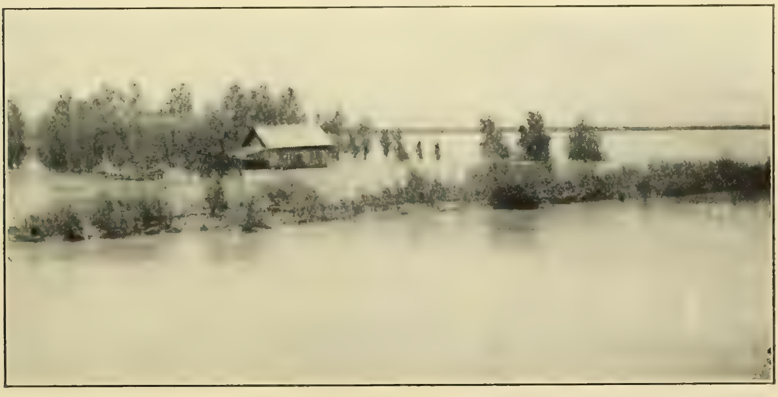

Fig. 3.—Overflow Against West and South Banks of Main Canal Near Five Gates, 2½ Miles Northwest of Calexico.

The Inter-California Railroad from Calexico toward Yuma had been constructed as far as Cocopah and practically all of this was under water. The Holtville Interurban Railroad, crossing the Alamo River, was cut out from time to time, the channel at that point being lowered more than 30 ft. This caused serious trouble with the discharge pipe of the Holton Power Company, the plant being left rather high, and considerable work was required to keep it from being undermined by side cutting. The head available, however, was increased by 30 ft.

When the grade of New River had receded to a point about 3 miles above the International Boundary Line, a large area of adobe formation was encountered, and the fingers of the stream began to eat away in various directions and threatened to tear up the country throughout that region in a frightful way. The rate of recession was also greatly slackened. Long before the peak of the flood had been reached, it was evident that the situation along the Central Main and at Calexico was very serious and must become much more so, until grade recession might give relief. It was decided, therefore, to use dynamite liberally in an endeavor to localize the New River's grade recession and to facilitate its progress.

From observations and soil and other data at the time available the probability seemed slight of such recession extending more than 6 or 7 miles beyond Calexico, or far enough to endanger lowering the water surface in the Alamo above the controlling works and so menacing the water supply of the valley before the summer flood of 1908. It was known that very large areas of adobe soil existed in the Garza's and Beltran's Slough country, so that the cutting there would be very much slower. There thus seemed to be considerable leeway, while the strain on the irrigation system of the valley was so severe at several critical points that it was utter nonsense to think it could be held through another flood season.

In this dynamiting, from eight to sixteen $\frac{1}{4}$-lb. sticks of dynamite were tied in a bundle about a fulminating cap connected with from 8 to 12 in. of water-proof fuse. The fuse was then lit and the bundle tossed into the water. A little practice and careful observation enabled one to become quite proficient in estimating how far the bundle of dynamite would be washed down stream by the current before the cap exploded the charge, and in placing the charge to get maximum results. Undoubtedly, the course of the grade recession was considerably checked and bad erosion somewhat mitigated by this work, but it is very doubtful whether the time of the grade recession's passing Calexico and Mexicali was markedly accelerated.

When this occurred the results were spectacular in the extreme, the rate of cutting back at this point being fairly uniform at 1 ft. per min. The side cutting of the east bank of the wide, deep barranca for several days threatened Calexico, and carried away a considerable part of Mexicali, including the railroad station, brick hotel, and a number of smaller buildings. The actual damage sustained was about $15 000 in Calexico and $75 000 in Mexicali.

For a short distance past Mexicali the cutting back followed the borrow-pits of the Inter-California Railroad, utterly destroying it and carrying away much of the track and trestle material. About a mile out of town, the grade rose slightly above the flood-waters, but farther on, for several miles again, the roadbed was practically destroyed, although no more track material was lost.

These flood-waters covered about 6 000 acres of cultivated farms, of course, utterly ruining the crops. Greater damage, however, occurred as the grade receded and the water rushed from each side toward the newly-made channel, resulting in cutting back fingers or side cañons from the main stream to distances and depths depending on the length of time required to drain off the contributory water. Some of these side cañons extended back from 2 000 to 2 500 ft. It thus happened that about 3 000 acres of improved and 10 000 acres of unimproved land were eroded to such an extent as to be practically ruined for agricultural or any other purposes. Of this area, about 7 000 acres were public land. The area occupied by the New and Alamo channels themselves was increased by about 7 000 acres.

The greatest damage in the Imperial Valley proper, however, was caused by the destruction of the flumes in the West Side Main over New River in Mexico and the Central Main over New River northwest of Imperial, leaving Mutual Water Companies 6 and 8 without water until January, 1908. These two districts contained about 30 000 acres in actual cultivation, and were rendered practically uninhabitable and absolutely waterless for about 1½ years.

Except as noted, agricultural operations in the valley were facilitated by the flood, there being at all times plenty of water in the canals. Prospective settlers, of course, were kept away almost entirely, but the inhabitants of the valley displayed a remarkable confidence that the trouble would be overcome, and business was not affected very seriously. Indeed, during these very times, the new and independent town site of El Centro was the scene of really wonderful building activity, and the Holton Power Company, directly and indirectly, practically doubled its plant and holdings in the valley.

The effect of this flood, in a geological way, was of extraordinary interest and very spectacular. In 9 months the runaway waters of the Colorado had eroded from the New and Alamo River channels and carried down into the Salton Sea a yardage almost four times as great as that of the entire Panama Canal. The combined length of the channels cut out was almost 43 miles, the average width being 1 000 ft., and the depth 50 ft. To this total of from 400 000 000 to 450 000 000 cu. yd. must be added almost 10% more for side cañons, surface land erosions, etc. Very rarely, if ever before, has it been possible to see a geological agency effect in a few months a change which usually requires centuries.

PREPARATION FOR DIVERSION WORK.

All measures to prevent avoidable damage to the irrigation system in the valley from the flood-waters having been arranged, operations were resumed on the river. The break opposite the wooden head-gate had been widened during the flood from 600 ft. to more than ½ mile, and necessitated work on a far larger scale than had ever been suggested. The opinions to the contrary notwithstanding, the ability to get rock in large quantities and rapidly seemed to the writer to be so essential, and it was so obvious that much better transportation facilities were required, that it was decided to build a branch railroad from the Southern Pacific main line at a point 7 miles west of Yuma (now known as Hanlon's Junction) to the break.

The located line of the Inter-California Railroad, construction of which had been stopped by the overflow waters at Cocopah, ran only a few hundred yards west of the wooden head-gate and 150 ft. west of the concrete head-gate. This Inter-California Railroad is a Mexican subsidiary of the Southern Pacific Company, and it was not difficult to arrange a change in its alignment to cross the Alamo where the best location for the diversion dam could be found and to build at once that portion from the break north to the concrete head-gate. Thence northward the permanent alignment was expensive and would require considerable time to construct, therefore it was decided to make a temporary connection of about 6 000 ft. from Hanlon's Junction to the concrete head-gate. It was arranged that the Southern Pacific should build the entire branch line and charge the total cost. on a force account basis, to the C. D. Co., and when later, if ever, the Inter-California Railroad should be completed, all that portion of the branch which could be incorporated with the permanent alignment of the road would be taken over by it at such a figure as it would cost at that time. The stretch from Hanlon's Junction to the western line of the lands of the C. D. Co. is in the Yuma Indian Reservation, and, according to the rules and regulation of the Interior Department, it would have taken some time to acquire a right of way for this portion. As it was feared that special permission might not be quickly obtainable, nothing whatever was said, but the line was simply built. Such a course was deemed justifiable, considering the gravity of the situation, the necessity for haste, and the very small discretionary powers given to Government officials in such cases. As soon as the existence of this track was no longer absolutely vital, permission was requested in the usual way and in due course was obtained. Construction of this branch line was begun on July 1st, and on August 15th the first train load of materials passed over it to the Lower Heading.

Quarry.—The granite point of rock on which the concrete head-gate was founded seemed favorable for quickly developing a quarry where a large quantity of rock might be obtained, and instructions were given to do the best possible with it. The rock is a second-class granite, and, before the first closing was completed, a quarry had been developed with a 600-ft. face averaging 40 ft. in height. The development of this quarry and track room for outfit cars, locomotives, etc., called for the building of a large yard of sidings and spurs. This quarry was entirely on C. D. Co. land—that bought from Hall Hanlon at the very beginning.

Clay Pit.—Between the quarry and the Boundary Line, and about $\frac{1}{4}$ mile west of the branch railroad, there was an opportunity to develop rapidly a clay pit. Advantage was taken of this, and by the time the first closing was completed, there was a steam shovel face, 600 ft. long and averaging 60 ft. in height. The clay in this bed is rather hard and requires some blasting, but it melts down in water, and when mixed in about equal proportions with the cement gravel from the Mammoth gravel pit makes a very impervious material for dam construction.

The Mammoth Gravel Pit.—This pit is on the Southern Pacific Railroad 41.08 miles west of Hanlon's Junction. It had been thoroughly developed at that time and had been used for ballasting the main line for more than 100 miles in each direction. It is the property of the railroad, and the material obtained there is fairly high in clay, the result being essentially a cementing gravel, which makes the surface of the track almost impervious.

Other Quarries Available.—At Declez, a point on the Southern Pacific Railroad 195 miles west of Hanlon's Junction and 49 miles east of Los Angeles, there is a large, well-equipped quarry of very good granite, from which material for the construction of the breakwater at San Pedro Harbor, 19 miles southwest of Los Angeles, is obtained. The output of this quarry is very large, the rock running up to 12 tons.

Near Ogilby, 7 miles west, a large area is covered with lava "nigger-head" rock, essentially one- or two-man size, which had been in part denuded to furnish rip-rap around the railroad bridge over the Colorado at Yuma. The tracks, however, had been torn up, and no stone had been obtained therefrom in years.

At Tacna, 52 miles east of Hanlon's Junction, there was a quarry formerly used by the railroad but abandoned because the rock therefrom was small and of poor quality.

At Patagonia, on the branch line south from Bunson toward Nogales, and 370 miles east of Hanlon's Junction, there was a well-equipped quarry controlled by the Southern Pacific. Its output was a reddish limestone, considerably smaller than that at Declez, but yet frequently turning out 10-ton rock.

These four sources of supply constituted the utmost possibilities, aside from the quarry which might be developed at Andrade.*

Brush.—By no means all the area contiguous to the Colorado is covered with willow brush, but it occurs in spots, often of very large extent. Such areas on the west bank of the river near the Edinger

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* Andrade is the name of the Inter-California railroad station on the American side of the Boundary Line, Algodones being on the Mexican side.

Dam had been cleared away, and west of the old Main Canal there was an old shallow lake which, though now drained, was practically barren. All brush, therefore, had to be obtained from the south side of the break, and with an average wagon haul of about 1 mile. The growths, ranging from 6 to 18 ft. in height, were ideal for fascines and mattress work. Main and branch roads were cut by Indian labor in order to get this material to the front rapidly.

Dredges.—The dipper dredge, *Alpha,* and the suction dredge, *Beta,* were in reasonably good condition, but the former could not be used in the sand bar left exposed in the bottom of the break when the waters receded, because the material slipped down to such a flat slope that it would have imprisoned the craft. After doing all it could in the by-pass and more solid ground, it was started to deepening the old Main Canal toward Algodones. Dams were built behind it from time to time, and water was pumped into the canal at the upper intake to keep the machine afloat. The quantity of water required indicated a surprisingly small seepage loss from this old canal into the surrounding country, and this is in accord with the unexpected experience with the coffer-dams of the wooden and concrete head-gates.

Steamers and Barges.—During the latter part of 1905 the Mexican Co. purchased the steamer, *Searchlight,* 91 ft. long, 18 ft. wide, and drawing, without load, 18 in. of water. It had a barge, about 55 ft. long and 25 ft. wide, on which most of its load was carried. The steamer, *Cochan,* 135 ft. long and 31 ft. wide, the largest on the river, belonged to Yuma parties, and as it had been leased by J. G. White and Company for hauling materials and supplies to the Laguna Weir, it was not available. There was another steamer on the river, the *St. Valliers,* 75 ft. long, which was a little smaller than the *Searchlight* and in very poor condition. In addition to these there was the barge *Silas J. Lewis,* 115 ft. long and 35 ft. wide, which was fitted with a donkey engine with which it was pulled up stream. This barge was rented for $15 per day, and its deck was cleared for mattress weaving.

Grading Outfits.—The Southern District of the Southern Pacific Company—from Santa Barbara and Fresno, Cal., to El Paso, Tex.—has enough reconstruction and betterment work to keep two or three grading contractors' outfits at work except during the very hot season. An arrangement was made with one of these, Shattuck and Desmond, to supply an outfit on the force account schedule paid by the railroad, with provisions for the payment of all duties and for all stock dying from heat. This firm secured, fed, and boarded its own laborers. Inasmuch as there was no very definite plan as to the work which would be required, no contracts were feasible, hence the force account arrangement. At one time about 800 head of this firm's stock, with complete camp equipment, Fresno scrapers, plows, etc., were on the work.

Materials and Stores.—Arrangements were made with the Southern Pacific for equipment, materials, and stores on the basis of cost plus 10%, and for freight charges of 0.5 cent per ton-mile, until the provisions of the Interstate Commerce Commission prohibiting such freight arrangement went into effect. Two steam shovels were brought in for quarry work and one for the clay pit. Complete work trains were requisitioned from time to time until a maximum of ten was reached. A roundhouse foreman and an assistant master car repairer were sent by the railroad company, and temporary, but effective, plants were installed at Andrade. Three carloads of repair parts and stores for engine, car and air-brake repairs were sent out, used from, and returned when the work ended. All requisition blanks, rules, and other organization methods of the railroad were continued.

When the Southern Pacific built the Lucin Cut-off, consisting of a long trestle bridge and an immense fill across Great Salt Lake, in Utah, there were bought a large number of steel side-dump cars, of 45 cu. yd. capacity, locally known as "battleships," weighing approximately 20 tons, and having a capacity of 100 000 lb. with a permissible 10% overload. These cars were frequently loaded to 125 000 lb. on this work, as the trip between the Andrade quarry and the break did not exceed 4 miles. At first 80 of these cars were secured, and more and more were sent until about 300 were finally in service. Such a quantity of railroad equipment necessitated rather extensive terminal facilities, and these were provided on the American side of the line because of the customs regulations of the Mexican Government.

The railroad from Hanlon's Junction to the Lower Heading, the quarry, clay pit, steam shovels, etc., were under Mr. Eulogio Carrillo, Assistant Engineer of the Southern Pacific Construction Department, from June 1st, 1906, to July 21st, 1907, as a superintendent of the C. D. Co., from which he received his salary, the railroad giving him leave of absence for that period. All the men under his direction, however, were carried on the Southern Pacific payrolls, and bills were rendered later by that corporation to cover this expenditure.

There were two reasons for having the railroad company supply so great a quantity of labor, equipment, materials, and supplies. First, it afforded an opportunity to assemble quickly a thoroughly organized and efficient force of men; the advantage of obtaining materials and supplies at low prices by the purchasing department of the Harriman systems; immediate shipment of repair parts not kept on hand, thus reducing delays to the minimum; and the ability to increase or decrease rapidly the force and equipment without confusion. The second reason was that no immediate cash was required, and as bills of all kinds were not usually presented and approved in less than about 6 months, approximately 3% in interest was saved. All bills were rendered at actual cost plus 10%, which thus meant really cost plus 7%—a very low figure for superintendence, etc.

Whenever any train, equipment, or men left the main line and came on the branch line they reported to and were under the jurisdiction of Mr. Carrillo, who in turn reported to and was under the sole jurisdiction of the writer. In this way no misunderstanding arose, and the entire force obeyed instructions issued as quickly and fully as though there were absolutely no connection between them and the Southern Pacific.

Storehouse at Lower Heading.—Duty had to be paid on everything taken into Mexico, but, nevertheless, a very complete storehouse of repair parts, small tools, etc., was established at the Lower Heading. No requisition system was put in, however, because it was felt that the losses which would thus occur would amount to much less than the delay due to any form of red tape, whatsoever. Everything received was charged to the work, and at its closing down an inventory was made and the work was credited with the value of the material left.

Climatic Conditions.—From about June 1st to the middle of September or October 1st, the temperature of this region is so high that until 10 years ago it was not considered advisable to continue large construction work during that season. There can be no doubt that ordinary labor is only from one-third to two-thirds as efficient in such heat, and during this particular year the general average seemed to be about one-half. There is little wind during this period, and the humidity is ordinarily very low, though occasionally it is quite high for periods of two or three days.

Mosquitoes are frequently a terrible pest, very often driving even cattle out of regions near stagnant water. There is relatively little vegetation about Andrade, and at the Lower Heading a large camp compound was entirely cleared and the stagnant pools in the vicinity drained at a slight cost, so that the mosquitoes, while annoying, were by no means serious.

Brush and arrow weed growths are so dense that white men, no matter how well acclimated, cannot work very hard in cutting them down. Men from the central part of Mexico were imported, but they could stand it little better. Indian labor is the only kind for that sort of work.

Labor Conditions.—The work of rehabilitating San Francisco after its disastrous conflagration drew there an immense amount of shifting labor. To the south Los Angeles was growing in every direction. The Harriman Lines, under President Randolph, was employing large numbers of men constructing the West Coast Railroad from Guaymas toward Mazatlan and Guadalajara. Much betterment work was in progress on the lines from Los Angeles to El Paso, and large forces were required for building "shooflies" and shifting track along the Salton Sea. J. G. White and Company were rushing work on the Laguna Weir, and the Reclamation Service was building the Roosevelt Dam near Phœnix. Thus the labor situation in California as a whole, and in this part of California in particular, was acute. The immigration laws of the United States prevented the importation of Mexicans, except in a very small way, but here the work was in Mexico. It was decided, therefore, to obtain laborers from Central Mexico, ship them from El Paso to Yuma in bond, and back into Mexico at the Lower Heading. Arrangements were made with the Labor Agent for the Southern Pacific, Southern District, Mr. Ben Heney, of Tucson, to ship 500 men. This plan was an utter failure, for two reasons. The Mexican officials did their best to prevent Mr. Heney's agents from getting men started, and the 75 men who arrived were unable to stand the climate.

Attention was then turned toward getting Indians in large numbers, and arrangements were made with Mr. C. E. Dagenette, Indian Outing Agent, with the result that, by the time work was in full swing, practically all the men, women, and children of six Indian tribes were on the work—the Pimas, Papagoes, Maricopas, and Yumas, from Arizona; and the Cocopahs and Dieguenos, from Mexico. These six tribes fraternized and got along together without any difficulties whatever, and constituted a separate camp of about 2 000 people. About 400 workmen could be depended on from this collection. They were paid 20 cents an hour, and every 9 men received in addition one man's pay to go to a squaw for cooking their food. The Indians bought their own supplies, and to avoid duty built their camps on the Arizona bank, crossing the dry channel below the break to and from work.

Indian labor was very satisfactory, and, indeed, just what other arrangement could have been made is very problematical. Under intelligent foremen who understand their peculiarities, chief of which is lack of assurance and consequent timidity in going ahead with work, they are quite satisfactory. They must be paid weekly, and very few can ever be induced to work on Sunday or to put in overtime, regardless of how critical the stage of work may be when the whistle blows.

Very fortunately, indeed, an unexpectedly large amount of floating labor came in from every part of the United States, men who are attracted to any work which has achieved notoriety for any reason. Once on the ground these men did not work any great length of time. A work train ran into Yuma every night for provisions and supplies, returning early in the morning, and it always carried a considerable number of cheerful capitalists out and sadder and wiser men in. Yuma at that time was "wide open," with all sorts of lures which few of these floaters could resist. To what extent the work would have suffered had Yuma then been a closed town, as it is now, is a question.

The general wages paid were:

Pile-driver foreman	50	cents per hour.
Pile-driver donkey runner	43¾	" " "
Good pile-driver helpers	31¼ to 37½	" " "
Ordinary labor	27½ to 30	" " "

Work from 8 to 10 hours per day.
Board deduction, $22.50 per month.

Commissary and Camp Plans.—The usual outfit cars were provided for all men carried on the rolls of the railroad, and many were boarded in the dining cars, which were a part of Mr. Carrillo's permanent construction outfit. The remainder of the men were boarded by Mr. M. C. Threlkeld, of San Francisco, who had and still has a contract with the railroad to board all gangs engaged in maintenance of way and betterment work on its lines. Mr. Threlkeld took an essentially similar contract for feeding the white laborers of the C. D. Co., the first contract being for 25 cents per meal in the United States and 40 cents in Mexico, the contractor to pay all customs duties on material and supplies. After the second break, and when the work was continued at President Roosevelt's request, it was deemed probable that the Mexican Government would refund duties on provisions thereafter, so that the contract was changed on January 1st, 1907, to 25 cents per meal and the Mexican Co., to pay the duties. This contract covered meals for all white laborers, including men on dredges, on the steamer *Searchlight,* etc., and gave Mr. Threlkeld the exclusive selling of clothing, tobacco, notions, etc., to the laborers. The Indians bought relatively little from him, however, preferring to deal with Yuma merchants with whom the local Indians were very well acquainted.

Excellent board for the men was insisted on and furnished. It was believed that good board, especially with lots of fresh vegetables, would be a large factor in keeping men on the work, and this was found to be the case. Large numbers of mosquitoes were feared, in spite of precautions taken, so bunk houses were built, with brush ramada roofs, and carefully and effectively screened all round. These precautions were not exactly necessary, but were nevertheless well worth their cost.

Policing of Camps.—The many different classes of laborers on the same job and under Mexican laws made it essential to have effective police arrangements, and bar liquor from the camp absolutely. The Yuma Indian Reservation extends to the line, and, in addition was then and until 1908, a part of San Diego County, and a "dry" region. Across the river in Arizona is "wet," but the United States laws against selling liquor to Indians are rigorously enforced. In Lower California, however, the idea of liquor control has not even germinated, and it was necessary to promise to prevent American Indians from getting liquor in Mexico before permission could be obtained to take them out of the United States—and this was quite proper. Accordingly, arrangements were made with the Mexican authorities to put the entire region under martial law, and send a force of rurales with a military commandant at their head to police the camps. This proved extremely efficient and satisfactory, and there was absolutely no disorder at any time.

Customs and Duties.—Except for the operations of the C. D. Co., there was no development in Mexico along the river, therefore, until 1908, the nearest custom house in Lower California was at Mexicali. A garrita was maintained at Algodones, however, where material going down the river to land in Mexico was passed. During the construction of the Edinger Dam, all camps and supplies were kept on Disaster Island in the middle of the river, so that there were no customs charges. When the construction of the wooden head-gate was begun, endeavors were made to get the Mexican Government to establish a customs office at Algodones temporarily, but without success. Accordingly, all bills of material to be passed had to be sent to the custom house in Mexicali; there the charges were assessed, and the manifest was returned to Algodones before the goods could be taken over, which was very cumbersome and slow.

Another method of getting goods across the line was taken advantage of, namely, by boletas. The Mexican Government permits each individual, on payment of duties, daily to take across $20 (Mexican) worth of dutiable stuff without manifest, and the authorities agreed to permit goods to be passed at the Algodones garrita by this boleta method, having individual employees of the company sign the boletas. In this way emergency stuff was passed.

Under the concession of the Mexican Co., machinery and materials for permanent construction was to be admitted without duty, but the intention of this provision was plainly for the company to make out a list of what would be required once for all, and that such freedom from duties would apply to the original entry of the machinery and material, and not to subsequent repair parts, etc. Obviously, it did not contemplate the refund of customs charges in such a case as closing the crevasse. Nevertheless, it seemed probable that the customs charges for material and supplies other than provisions would be refunded, because the Mexican Government itself was vitally interested in stopping the break. Tentative negotiations toward this end were started, but the procedure for securing such permission is a long one, and it was advised that the work be prosecuted and the request for refund made after its completion. It was also made plain that no refund would be given for duties on provisions, as it was impossible to determine that the provisions passed were all actually used on the work. When the work was completed a request for a refund was made, and, on President Diaz's recommendation, the National Congress, by vote, refunded approximately 75% of all duties paid, amounting to more than $40 000.

The chief objection, therefore, was the red tape involved in passing goods, and the delays which followed any slight technical mistake in classification. As an illustration: an inspector investigated the customs transactions of the period about a year later, and assessed a fine against the company for $3 000 for utilizing the boleta method of passing emergency materials and supplies. On proper presentation of the facts, however, this fine was remitted. Stock with harness and grading equipment was permitted to be passed into Mexico under bond for a period of 6 months, as also was machinery, which provision assisted very greatly in the work.

All payrolls, time checks, receipts, and legal papers require stamps to be affixed and cancelled, inspectors from time to time visiting all corporations and checking the books. If any irregularities are found in the books or papers for the 6 months immediately preceding, such inspector is then permitted to go back to the period of 6 months immediately preceding that, etc. If, however, everything is regular for the first 6 months preceding, that operates to prohibit inspection prior to that time. These inspectors get a considerable percentage of fines assessed and collected, and are consequently quite zealous, so that it is profitable to obey the stamp law scrupulously.

Necessity for Mexican Corporation Doing Work.—On taking charge of the affairs of the Mexican Co., the writer found that up to that time work done in Mexico had been paid for on the American side of the line through the C. D. Co., and in this way no Mexican stamps were required for payrolls, time checks, etc. In other words, the C. D. Co. had its forces go over into Mexico and do work on the canals of the Mexican Co. directly. As this was obviously contrary to the spirit of the Mexican laws on the subject, arrangements were made at once whereby the Mexican Co. did all work in Mexico and billed the C. D. Co. therefor at actual cost, the C. D. Co. turning over all materials and supplies required on the Mexican side of the Line at its expense.

Mr. A. F. Andrade, now Depositario for the Mexican Co., and Assistant General Manager of the Inter-California, was made General Agent of the Mexican Co., and was in charge of all negotiations between that corporation and the Mexican Government, and to his tact, energy, and ability is attributed the relatively small amount of irritation and delay encountered.

Occasionally, rules and regulations had to be disregarded, and this was done when it was deemed quite necessary, knowing that the local officers would report such infractions of the laws, but that the higher officials would view such infractions very sensibly when sooner or later brought to their notice with full explanations. For example, before permission was given to run trains into and out of Mexico after dark, a serious situation developed just at sundown, immediately requiring rock at the Lower Heading, and the Mexican officials at the Boundary Line would not permit trains to pass. Their protests were disregarded, for while the officials under the circumstances could not act otherwise, it would have been folly not to have disregarded their orders, considering the urgency of the matter. Proper explanations were at once made, and the company was not criticized in any way for the action.

Difficulties in doing work in Mexico are largely due to ignorance of Mexican conditions, customs laws, and personal characteristics, and doubtless are no greater than a Mexican would encounter in doing work in the United States. It is very desirable for the highest officer in charge of work to speak Spanish well, as minor Mexican officials are far more impressed with a statement coming from him than from any subordinate officer.

Methods of Diversion of River Through Rockwood Head-Gate.

The triangular space between the two faces of the **A**-frame and the horizontal cross-bracing of the wooden head-gate was made into a long pyramid, by flooring the bottom and sides, which was filled with sand taken in by wheel-barrows, in order to give additional weight to the gate in resisting the buoyant effect of the water.

By August 5th the discharge of the river had fallen to 24 500 sec-ft., and directly beside the Rockwood Head-gate the receding waters had exposed sand bars on each side of the main channel—the situation being as represented by Fig. 15. When these sand bars had dried sufficiently, teams were used in throwing up an embankment on the line of the diversion dam. Brush jetties were also used to narrow the channel, the *Beta* assisting. In a little more than a week the stream was narrowed to 600 ft., the river gradually falling. Work was then begun on weaving a brush mattress, 100 ft. wide up and down stream, and sinking it on the bottom of the river. The decks of the barge, *Silas J. Lewis,* were cleared and skids were rigged thereon; ½-in. steel cables, 8 ft. apart, were anchored to "dead men" in the north bank and unwound from spools beneath the skids, such cables constituting the longitudinal strength of the mattress; and to these were fastened brush fascines averaging 18 in. in diameter and 100 ft. in length. These fascines were built up between vertical pins at the upper end of the skids and bound with baling wire, and as they were completed they were pushed down to the last one in the mattress and sewed to it and to the supporting cables with ⅜-in., 9-strand, galvanized-iron cable and cable clamps. Fig. 1, Plate CXV, shows the method of sewing and fastening. When a length of mattress equal to the width of the barge was completed, the barge was slowly pulled from under it, and it caught the silt and at once settled heavily to the bottom. No kind of weighting whatsoever was required. Another barge width of mattress was then woven and sunk, and so on. Figs. 1 and 2, Plate CXV, show the method of constructing the mattress and the number of men employed.

It required 20 working days, with two shifts, to weave and sink two mattresses, one on top of the other, across the bed of the stream, or a total of 1 300 ft.; thus the average rate was 65 lin. ft. or 6 500 sq. ft. daily. The work went ahead without interruption or difficulty except that once the anchor lines controlling the barge were not handled with sufficient care and the first layer of mattress was not sunk across in a straight line, but curved down stream in the middle perhaps 20 ft. at the maximum point. This, however, was not important.

The prevailing idea as to the necessity for such bottom protection in the river may be better realized from the fact that several engineers with the longest experience on the river joined in urging that a solid canvas back be sewed on the under side of the mattress. It was feared that the water might start a wash through a break in the mattress, that such a stream would carry the sand from below, cause a depression for the mattress to span, and result in breaking it when weight should be put on above. This, however, was deemed unnecessary.

While the mattress work was being completed, a 4-pile railroad trestle with 10-ft. bents was started across the center line of this foundation, decked, and a railroad track built thereon. This trestle was driven from both ends, and was ready for the passage of trains on September 14th, 6 days after the completion of the mattress. In the mean time, the earthwork across the north sand bar had progressed sufficiently to connect the rails, so that trains could run out on the trestle. On the south side, the jetty work and the *Beta* had built up a sand bar on which a frame trestle on mud-sills was erected, connecting the earth embankment on the south sand bar to the trestle, thus affording tail room for trains. This frame trestle was filled in with material from the clay pit at Andrade.

At this stage, brush fascines were put in between the bents of the trestle over the channel, laid longitudinally with the stream, and sunk by rock from the quarry at Andrade. The rock was loaded into "battleships" with a steam shovel, hauled down, and dumped from the trestle. In this way a difference of 6 ft. in water elevation above and below this diversion dam was attained with no difficulty whatsoever.

Meanwhile the by-pass in which the Rockwood head-gate stood was being enlarged in several ways. The *Alpha* had cut a small channel from the crevasse to the gate from above and from below, through the solid ground, and the *Beta* had enlarged these cuts until it was taken over to assist in the jetty work on the south side of the river. A small ditch was cut with teams and scrapers across the sand bar, as an extension of the down-stream end of the by-pass. This channel was excavated to the water-table with Fresno scrapers, and made as narrow as possible, reliance being placed on enlarging it by the erosion of the water. In two or three places adobe deposits of considerable extent were found, and in these dynamite was used, as already explained.

The steamer, *Searchlight,* was anchored in the upper by-pass for two or three days with its rear end against the bank and the stern wheel kept going as fast as possible. This greatly hurried the erosion. The increasing head on the diversion dam aided these methods of enlarging the capacity of the by-pass until on October 10th only

PLATE CXV.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.

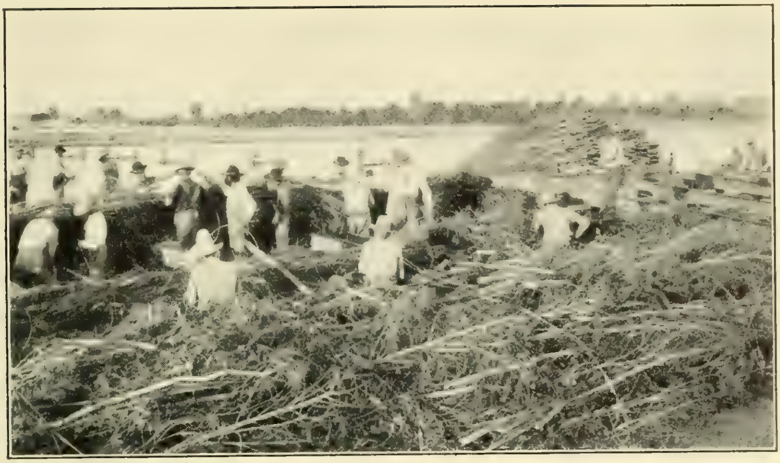


FIG. 1.—WEAVING BRUSH MATTRESS.

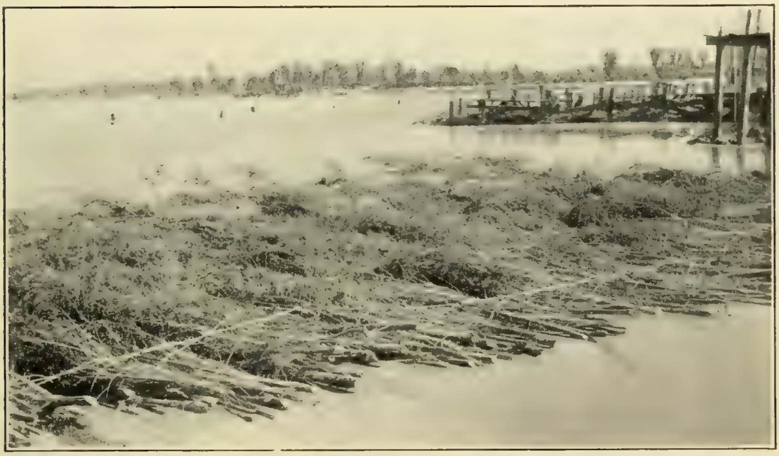


FIG. 2.—DOWN-STREAM END OF BRUSH MATTRESS ABOVE WATER BECAUSE OF SILTING ACTION.

about 1 450 sec-ft. of the river's total discharge of 14 300 sec-ft. was not going through the gate.

The alignment of the by-pass was unfortunate, as it had quite a sharp curve, and the upper end left the river at a sharp angle. At this point cutting began, and to prevent it a small brush mattress was woven and weighted down with rock.

It was soon seen that, with the 4-ft. openings between them, the **A**-frames of the gate caught the drift in the water very badly. Anticipating this, cables had been stretched across the entrance of the by-pass and fitted with grab-hooks, like fish hooks on a trout line. These grab-hooks were of ⅜-in. wrought iron fastened with from 6- to 8-ft. lengths of sewing cable to the cable spans at intervals of about 8 ft. It was hoped that these would catch drift where it could easily be removed, and prevent trouble at the gate. However, they did very little good.

When the current through the gate increased to 6 or 8 ft. per sec., a scour developed both above and below. Soundings showed that the scour below the gate was not at all serious, but was really far less than had been anticipated. The eddies at the ends of the gate caused side-cutting, as is always the case, but really nothing alarming. The scour above the gate, however, was surprisingly great; some was expected, but not nearly as much as occurred. Brush and rock extension of the apron, as shown on the plans, had not been put in as it had been the intention to use rock from Andrade in lieu thereof. When soundings, which were taken frequently, showed that the by-pass bed was eroded to the level of the floor of the gate, approximately 1 000 cu. yd. of rock were loaded on a barge which was swung in front of the gate and held by cables until unloaded.

FAILURE OF WOODEN HEAD-GATE.

On October 3d a serious settlement of the earth filling in the north abutment suddenly occurred. Excavation was at once made to ascertain the cause, and some small leaks in the end wall on the up-stream side of the **A**-frame were found. These were stopped up, and the earth was leveled to only a few feet above the water surface on the outside. Two days later the lower wing-wall in this same abutment spread out at the bottom on the west side, as shown in Fig. 1, Plate CXXII. The gate itself buckled up about 0.3 ft., about one-third of its length from the abutment, such buckling apparently occurring very slowly within 24 hours, ending on October 5th. These signs of weakness were accompanied by the tearing up of the up-stream apron in relatively small sections, which were at once thrown against the **A**-frames by the current. With great difficulty these were taken out piecemeal, and then only in part. These, together with the drift which accumulated, caused a head of 4.4 ft. on the gate on October 11th. At this time the discharge through the gate was about 12 000 sec-ft.; the maximum discharge through it was about 13 000 sec-ft. on October 8th.

These indications of weakness showed that it would not be safe to use the gate after closing the break, and that it would be very fortunate if it held until this could be accomplished. Furthermore, the drift made it very difficult, if not impossible, to set the flash-boards. Accordingly, on October 5th, a pile bridge was begun just above the gate and connected with the track to the south by a frame bent trestle supported on mud-sills—the same construction as had been utilized on the south side of the channel. This trestle was finished in the morning of October 11th, and it was intended to dump rock from it and fill up the gate in this way and not attempt to use the flash-boards.

When the first rock train was slowly pushed over the trestle, at 11 A. M., three bents of the frame trestle settled and wrecked the train, fortunately injuring no one seriously. Just why construction which on apparently worst ground on the south side of the main channel was entirely satisfactory should have failed here, is not known—things happened thereafter too rapidly to find out. At any rate, had the trestle stood and had the large number of loaded "battleships" held ready been dumped, the writer has always believed that the head-gate would not have failed utterly. Be that as it may, at 2:30 P. M., without any warning, the gate suddenly buckled up at a point about one-third of the way from the south abutment, and the larger portion—from there to the other abutment—floated down stream about 200 ft., where it lodged. The remainder of the gate stayed in place, although it settled in the central end. When the gate went out, the 4.4-ft. head above it caused a destructive wave of water, carrying large quantities of drift and débris from the wrecked gate against the railroad trestle crossing the by-pass about 300 ft. below. In about 5 min. this

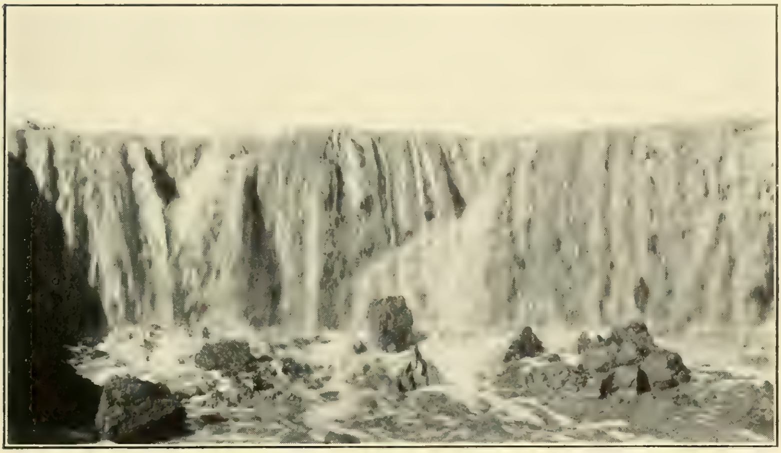


FIG. 1.—GRADE RECESSION IN NEW RIVER NEAR CALEXICO. MAXIMUM RATE OF RECESSION, 1 FOOT PER MINUTE. DROP, 28 FEET. JUNE, 1906.

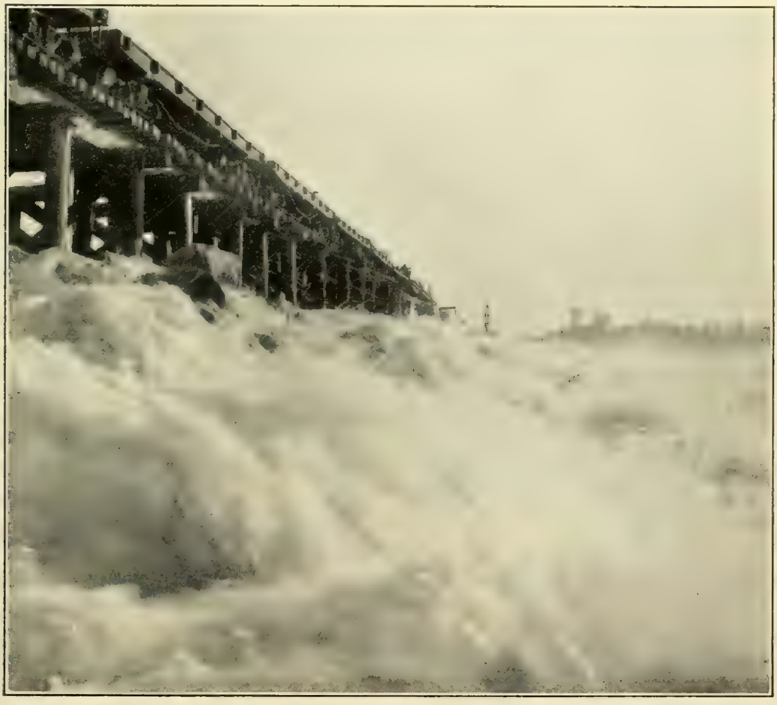


FIG. 2.—THE HIND DAM, PASSING 7 000 SECOND-FEET. HEAD, 10 FEET.

damaged the trestle seriously, and would have marooned a locomotive and train standing on the south side of the by-pass had not the engineer taken chances and pulled across before the piling began to go out.

The pond above the diversion dam extended some distance up stream and contained a large quantity of water which had to run out before the flow through the by-pass was reduced to the discharge of the river. By the time this occurred, considerable inroad had been made at the point where the upper by-pass left the river—which had been protected by a small brush mattress—and for a time it threatened to work down to and through the earth portion of the dam. Aggressive work was centered there, and such action was finally arrested.

Closing the Break with Rock Fill Barrier Dams in Series.

The lowering of the water above the diversion dam left it dry, except for a surprisingly small quantity of leakage, and enabled examination of the rock fill which had been produced by an ever-increasing proportion of rock with respect to brush. This condition of affairs seemed to indicate that the reasons urged why a rock fill dam of considerable height could not be built in a running stream were not altogether strong, and suggested the possibility of very quickly controlling the situation with a series of rock fill dams, each of which should sustain a head of not more than 4 ft. This particular dam had stood successfully a head of 6 ft. without any of the troubles prophesied for constructing rock fill dams in streams. Furthermore, the tracks of the Southern Pacific Company on the Salton Sea were in an extremely critical condition, and the southern transcontinental line would soon be interrupted, at an estimated cost of $1 000 000 a month. It was obvious that, if this were to be prevented, very quick action was necessary, and if hope should be abandoned, withdrawal of financial support in controlling the river was almost a certainty. Furthermore, other plans of controlling the situation possessed most serious difficulties, as already explained.

As a matter of insurance, however, a rush order was wired for additional sewing cable for building a diversion dam across the Colorado directly opposite the concrete head-gate, exactly as had been done successfully opposite the wooden head-gate to divert the river through the former structure, and as had been done with the other, trusting to dynamiting, dredging, erosion, etc., for enlarging the 4 miles of Main Canal thence to the break. This done, the trestles across the by-pass, above and below where the wooden head-gate had been, were repaired, and a third trestle, 30 ft. above the lower one, was hurriedly thrown across this stream, which was carrying the entire flow of the river, the waterway through the opening of the gate being only 120 ft. wide.

Such method of closing the break and forcing the river down the old channel by three rock fill barrier dams in series was therefore considered problematical only because there was no mattress under any of them, and the brush mattress idea had always been regarded as essential. The branch railroad from Hanlon's Junction to the Lower Heading was now in excellent condition, and the Andrade quarry was sufficiently developed to permit the use of the two steam shovels, producing about 5 000 cu. yd. of rock daily, by working night and day. It was felt that with these facilities, together with the rock which could be obtained from quarries within a distance of 400 miles to the east and west, rock could be put into the stream faster than the water could carry it away.

As a matter of fact, these three dams were built up so rapidly and successfully that only 10% of the water was going through the by-pass by October 29th, most of the remainder—8 600 sec-ft.—going over the diversion dam with the mattress foundation. Here, a secondary trestle, with 4-pile bents, 15 ft. apart, parallel to and 30 ft. up stream from the first, had been rushed, and from the two a rock fill dam was completed, turning all the water—9 270 sec-ft.—down the old channel and actually closing the break on November 4th. That is, after working on other lines continuously for 15 months, the stream was controlled by a rock fill dam in 24 days. In other words, the rock fill barrier dam plan, which had not been advocated, or indeed seriously considered, by a single man, proved to be a very simple and efficient, though expensive, method of re-diverting the river. The fact that there was a very substantial brush mattress foundation, however, was deemed by many as of vital importance.

Leakage through the structure was stopped by dumping "battleship" trainloads of gravel from the Mammoth gravel pit and clay from the clay pit, the whole being puddled with fire streams. The *Beta,* which was kept above the diversion dam in order to be taken up

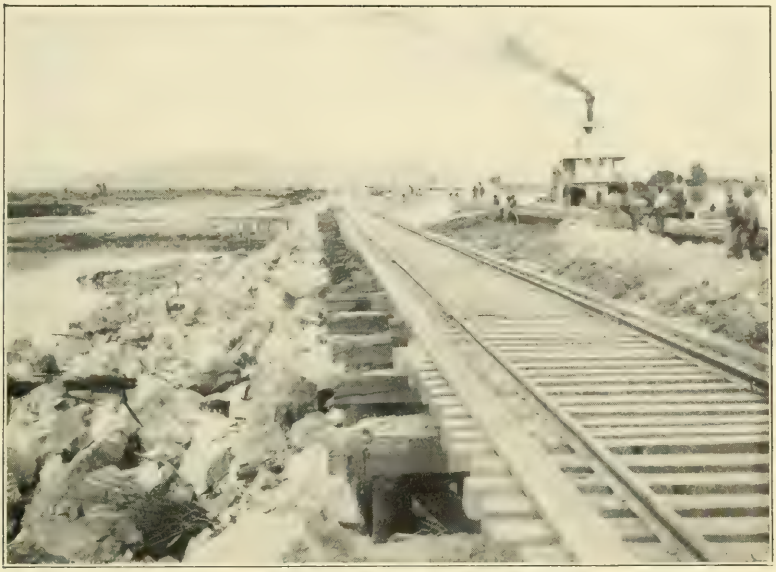


FIG. 1.—SEALING THE HIND DAM WITH GRAVEL AND CLAY BY HYDRAULIC JETS, NOVEMBER, 1906. NOTE SLOPE OF DOWN-STREAM SIDE OF ROCK FILL DAM.

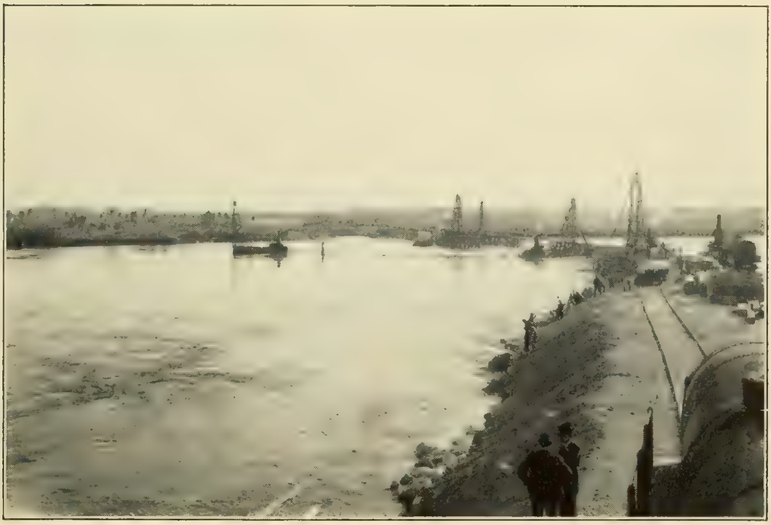


FIG. 2.—GENERAL VIEW OF THE SECOND BREAK, JANUARY 20TH, 1907.

the river and used in the intake above the concrete gate, was used in widening the up-stream toe of the dams.

A week and a half after the failure of the wooden head-gate, the success of the series rock fill dam plan seemed assured. The *Alpha* had finished its trip up the Main Canal and cut into the excavation in which the concrete head-gate had been built. The intake from the river to the concrete head-gate was completed, and by October 29th the river at this point had been raised approximately 4 ft. by operations at the break. The dam holding out the river here, and those which had been left by the *Alpha* on its way up, were blown out, and water commenced to flow through the concrete head-gate and Main Canal into the Alamo channel below the diversion operations. The initial discharge was about 150 sec-ft., and had increased but little when the river re-diversion was complete. At that time (November 4th) the water height at various points was as follows (C. D. Co. datum):

Above the dam..................	113.0 ft.
Below the dam..................	97.3 "
Opposite concrete head-gate....	114.5 "
Floor of concrete gate.........	98.0 "

By November 15th only 300 sec-ft. were flowing in the Main Canal, the fall of 17 ft. in these 4 miles not having resulted in much erosion, because of several stretches of adobe deposits, though the current was quite strong. Dynamite was used liberally, and by December 5th the grade recession was within 1 mile of the head-gate. In this way continuity of supply into the valley was kept up, and the water users suffered relatively little inconvenience.

In making the first closing, rock was unloaded from the three trestles across the by-pass and two trestles over the main channel. Records were kept daily of car loads of rock from Andrade and from the distant quarries unloaded from each trestle, but this record, unfortunately, has been misplaced, and the totals obviously signify nothing. As the quantities of various materials used during the entire period from August 1st to November 4th may be of interest, they are given in Table 13.

COMPLETING THE HIND DAM.

The dams across the break and the by-pass were hurried to completion with material from the Mammoth gravel pit and the clay pit at Andrade. It was decided that the structure should have a top elevation of 124, and that meant increasing its height fully 8 ft. The tracks over the trestles were raised so rapidly that no attempt was made to recover the stringers or caps.

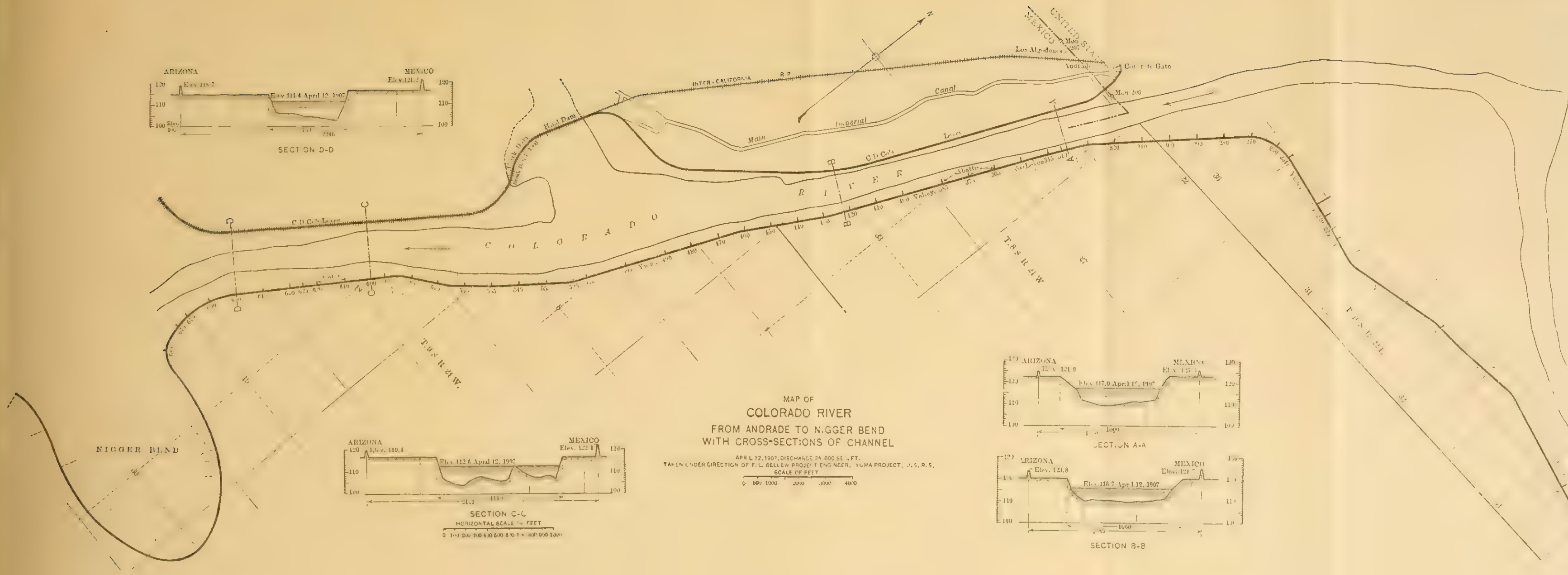
TABLE 13.—APPROXIMATE DATA OF CONSTRUCTING DIVERSION WORK ON COLORADO RIVER.

2 200 cords of brush and 40 miles of steel cable used in mattresses and shore protection.
3 800 ft. of railway trestle.
15 200 ft. of 8 by 17-in. Oregon pine stringers.
1 100 piles.
1 690 cars (50 000 cu. yd.) of rock (90% used from October 11th to November 4th).
841 cars (32 000 cu. yd.) of gravel.
808 cars (33 000 cu. yd.) of clay.
200 000 cu. yd. of earth, placed by teams.
200 000 cu. yd. of earth, placed by dredges.
200 to 500 head of mules and horses working from July to November 20th.
200 men in June, increasing to 1 000 men on November 4th.
Discharge of river, June 27th, 99 200 sec-ft.
Discharge of river when actual work of constructing channel was begun, August 6th, 24 400 sec-ft.
Discharge of river on November 4th, when final closing was made, 9 275 sec-ft.
Elevation of water above dam, 113.1 ft. above sea level (C. D. Co. datum).
Elevation of water surface below dam, 97.30 ft above sea level (C. D. Co. datum).
Total head on closing, 15.8 ft.
Elevation of water surface above dam one week after closing, 112.60 ft. above sea level.
Elevation of water surface below dam one week after closing, 95.85 ft. above sea level.
Total head on dam, November 11th, 16.75 ft.

The tracks were gradually pulled together to a final 13 ft. between center lines, which helped somewhat, but the proper side slopes were chiefly obtained with fire streams, five 1¼-in. nozzles, each throwing about 225 gal. per min., being used. The mixed materials as dumped assumed a slope of about 1¼ to 1, as a rough average, and these were very quickly and cheaply flattened down hydraulically to about 2¾ to 1 on the river side and 2 to 1 on the land side. Furthermore, the slopes were really well finished with very slight additional care and expense.

In its final form the dam has about 400 ft. of 15° curve at the north end, and 2 275 ft. of tangent; the dam is connected at each end with the levees extending along the river. At the north end there are 200 ft. of high dam with a rock fill core to within 8 ft. of the top —where it crossed the by-pass. A little more than half way toward the other end there is 600 ft. of another high stretch with a rock core on brush mattress foundation; the remainder is from 16 to 20 ft. high. This is known as the Hind Dam, so called after Mr. T. J. Hind, Superintendent of the work at the Lower Heading after June 1st, 1906, to distinguish it from the Clarke Dam, closing the second

PLATE CXVIII.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.



MAP OF
COLORADO RIVER
FROM ANDRADE TO NIGGER BEND
WITH CROSS-SECTIONS OF CHANNEL

APRIL 12, 1907, DISCHARGE 25 000 SEC.-FT.
TAKEN UNDER DIRECTION OF F. L. SELLEW PROJECT ENGINEER, YUMA PROJECT, U. S. R. S.

SCALE OF FEET
0 500 1000 2000 3000 4000

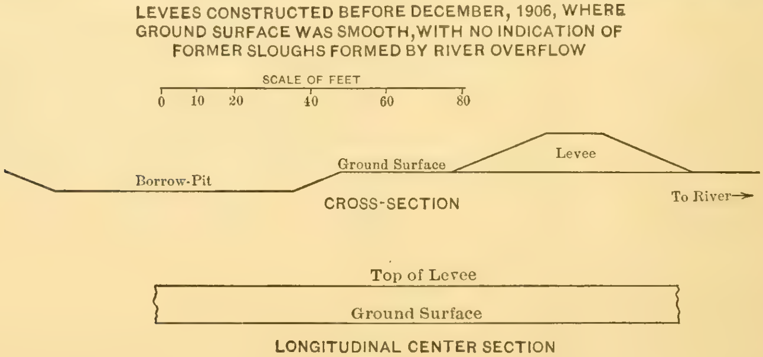
break, so called after Mr. C. K. Clarke, Superintendent of the second closing, December 20th, 1906, to February 20th, 1907. About 80% of this dam was complete on December 7th, 1906.

Levee Construction.

The original plans had been to connect the north abutment of the wooden head-gate with the embankment along the river side of the Main Canal, and to build a short section of levee to the south to prevent a flank movement of the river around the diverting dam. The enormous channel which the summer flood of 1906 created in the old Alamo made it obvious that, not only must the break be closed, but that, by a rather elaborate levee system, all overflow water must be kept from getting around into the Alamo. Surveys and examinations showed the necessity of an additional levee from the wooden head-gate to the concrete head-gate, and a levee from the diversion dam south for from 5 to 6 miles. J. C. Allison, Assoc. M. Am. Soc. C. E., Assistant Engineer of the Mexican Co., was assigned to make surveys for these levees on August 1st, and their location was completed early in September. The elevation of the top of the concrete head-gate was 124, and it was decided to put a track over this structure and extend it down the levees, so that the grade was made 126 at Andrade, 124 at the Lower Heading and over the Hind Dam, and thence for 4 miles south, generally 6 ft. above the old high-water marks. At all points the grade was kept approximately 2½ ft. higher than that of the levee opposite the Yuma Project, because, should the latter break, the damage would be far less than if the levees on west side were to fail, with re-diversion of the river to the Salton Sea. Between the head-gate and the Lower Heading it was necessary to locate the levee very close to the river, because it must obviously be between the river and the Main Canal, and some large areas of bad adobe, damp, and impossible to work with teams, lay close to the canal and extended well toward the river. Below the break, the levee was also close to the river, because of similar soil conditions for about 4 miles.

The levee was designed with a top width of 8 ft. and slopes of 2½ to 1 on the river side and 2 to 1 on the land side. The ground for the base of the levee was cleared and grubbed, but no "muck-ditching" was done. The desirability of muck-ditching was fully realized, and it was a part of the levee design. Experience in the valley had always shown that, not only ditch and canal banks, but low borders of irrigated fields, etc., leaked badly when water was first applied. Indeed, interesting cases were cited of water in considerable volume disappearing into the ground for several days, doubtless flowing away under the surface through partly opened cracks of buried layers of cracked adobe.

On the other hand, the money supplied by the Southern Pacific Company was for closing the break, and only for that purpose, until the re-diversion of the river was assured. No narrow construction was placed on this, to prevent building levees at all, but it was not considered proper to incur any avoidable expense in this direction until it should have been clearly demonstrated that it was physically possible to close the break. No muck-ditching had been done in levee building on the Yuma Project up to that time, and, besides, experience in the valley had always been that cracked adobe layers when thoroughly saturated and under the weight of a few feet of earth soon soften and the underground interstices automatically close. It was thought that the levees could probably be maintained until their bases would thus soak up tight, although it was certain that they would leak like sieves when water first came against them. Thus it was ordered that muck-ditch work be omitted.


LEVEES CONSTRUCTED BEFORE DECEMBER, 1906, WHERE GROUND SURFACE WAS SMOOTH, WITH NO INDICATION OF FORMER SLOUGHS FORMED BY RIVER OVERFLOW

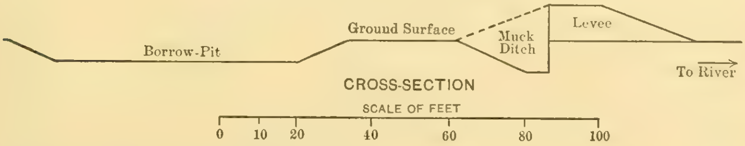
CROSS-SECTION

LONGITUDINAL CENTER SECTION

Fig. 18.

Material for the levees was taken from borrow-pits on the land side. It was fully realized that this was not in accordance with the usual practice, but it was decided on after careful consideration of the advantages and disadvantages. The location of the levee was forced very close to the river for a great portion of the way, and the levees of the Yuma Project on the opposite side were also so close to the stream that the distance between was in many places only 1 400 ft.—an exceptionally narrow waterway for such an unruly stream as the Colorado. As it was certain that the current at flood stages would be very great in such sections, it was extremely desirable not to disturb in any way the rank vegetation between the river and the levee, as it could not help but greatly break up and retard currents and thus protect the levee from erosion.

RECONSTRUCTION OF LEVEES WHICH WERE BUILT BEFORE DECEMBER,1906



Levees excavated with muck-ditch to section shown,and then refilled with good material to original section per dotted line

FIG. 19.

LEVEE CONSTRUCTED AFTER DECEMBER,1906

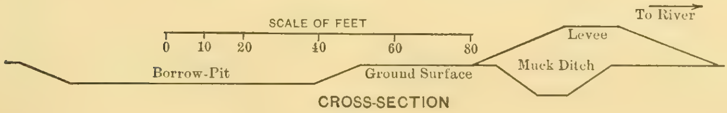


FIG. 20.

Experience with the levees of the Yuma Project showed that the hope that borrow-pits would be silted up was vain, and instead, that they would be cut together to form a continuous canal having eddying currents below the traverses during high floods, unless extensive brush abatis work was used. This sort of protection was deemed very unsatisfactory, because, though the Mexican Co. actually owns the land on which the levees were located in Mexico, it is practically impossible to exercise very much control over the Indians, owing to the indifference of local Mexican authorities. The Indians have always utilized any overflowed areas along the river as they wished, for their little garden patches, and these levees must absolutely cut off such water. For a long time it was utterly impossible to keep these nomads from planting seed in the borrow-pits, where the ground remains

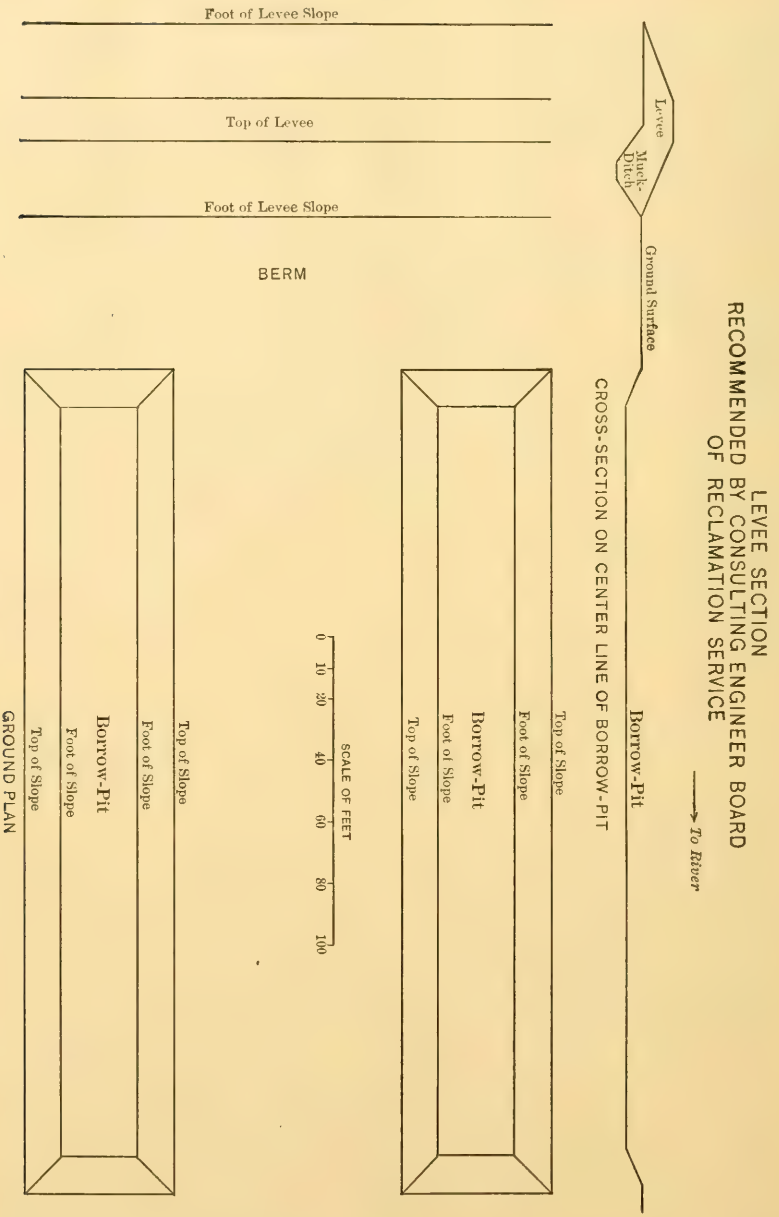

LEVEE SECTION
RECOMMENDED BY CONSULTING ENGINEER BOARD
OF RECLAMATION SERVICE
To River
Levee
Muck-Ditch
Ground Surface
Borrow-Pit
CROSS-SECTION ON CENTER LINE OF BORROW-PIT
Top of Slope
Foot of Slope
Borrow-Pit
Foot of Slope
Top of Slope
SCALE OF FEET
0
10
20
40
60
80
100
Foot of Levee Slope
Top of Levee
Foot of Levee Slope
BERM
Top of Slope
Foot of Slope
Borrow-Pit
Foot of Slope
Top of Slope
GROUND PLAN

Fig. 21.

wet the longest, and from destroying all brush growths that start therein. It was considered impracticable to maintain brush abatis work, which, when dry, would only make it easier to burn off the area in front of the levee for a garden clearing.

On the other hand, the land spoiled in making borrow-pits was of little value, being non-irrigable under existing conditions. There are no quicksand pockets above the water-table in that region, and, the soil being alluvial silt with more or less sand intermixed, there was consequently no fear of water-soaked material running, such as occasionally causes levee trouble elsewhere. There is also along the river no surface soil crust, which it is undesirable to disturb in levee building.

The only pertinent objection to land-side borrow-pits in this case, therefore, seemed to be the matter of increased total head, which it was decided did not outweigh the advantages of an undisturbed rank vegetation as a protection against the erosion of the water slope by swift currents.

These levees were built by the Shattuck and Desmond grading outfit on force account, with the intention of changing to a yardage basis as soon as possible. On December 6th, 1906, about 1½ miles above and below the dam, respectively, had been completed, 5 miles more were under construction, and the ground was cleared for another 2 miles.

Situation of the California Development Company and the Mexican Company.

About November 15th, 1906, the various operations along the river were making satisfactory progress, and the writer for the first time since June 1st left the river, hurriedly investigated the condition of the C. D. Co. and the Mexican Co. and reported his findings toward the end of that month. As a result of this, when the second break occurred a few days later, further advances by the Southern Pacific Company were advised against, and President Randolph concurred and so reported to Mr. Harriman. The fact that such a decision was made by the Harriman interests unqualifiedly has not been generally accepted without some mental reservations. It may be interesting, therefore, to make some excerpts from this report. The balance sheet for the combined C. D. Co. and Mexican Co. was approximately as follows:

Assets.

Real estate (chiefly in Mexico)		$545 037.26
Stocks (chiefly unsold water stock)		175 600.00
Plant:		
Machinery and equipment	$179 621.82	
Branch railroad track	63 000.00	
Canals in Mexico	375 000.00	
Canals in United States	308 616.37	
		926 238.19
Accounts receivable (chiefly notes secured by water stock)		235 137.02
Total		$1 882 012.47

Liabilities.

S. P. Co.—Audited bills and interest		$1 532 595.73
General audited bills and interest		73 786.72
Bonds and accrued interest		515 200.00
		$2 121 582.45
Damage claims (probable):		
New Liverpool Salt Co	$50 000.00	
Land owners	200 000.00	
Water Companies Nos. 6 and 8	500 000.00	
S. P. Co	1 000 000.00	
Inter-California R. R.—S. P	250 000.00	
		2 000 000.00
Total		$4 121 582.45
Net liabilities		2 239 569.98

The possibility of extending the canal system and selling additional water rights was discussed, and the opinion was offered that such possible returns would probably just about suffice for building a canal from the river into the valley, to take the place of the Alamo channel, which might be necessary in 5 or perhaps not for 20 years; and for building new controlling works on it in the valley.

The conclusions were that maintenance and operation expenses, properly estimated, would take up the returns from the sale of 600 000 acre-ft. per annum. The cost of protecting the region from the Colorado flood-waters was set down as problematic, probably averaging

$100 000 per year, and fluctuating enormously, and it was advised that the task of controlling the river was too serious a tax on the enterprise under any possible circumstances, while international complications would probably mean considerable delay in arranging for such work equitably and satisfactorily.

The Second Break.

On December 5th, 1906, a severe flood came down from the Gila, as shown by Plate CIX. Superintendent Hind and the writer, who were in Imperial Valley at the time, received telegraphic notice from the water-shed, and went at once to the river. For reasons already explained, trouble was expected from water getting under the levees, because no muck-ditch protection had been provided, and a large force of men was detailed to watch the sections for a mile on either side of the Hind Dam day and night as soon as water came even near the river toe of the levee. Information from the upper stations throughout the Gila water-shed frequently indicate floods which never materialize, and this was another case of the "truth itself" being not believed. There was so much accumulated work in the valley that there was no time to watch a discharge of 30 000 sec-ft., although a river stage which would test out and soak up the levees was obviously of great importance. Mr. Hind and the writer were in Yuma, returning to the valley, when the flood reached the Lower Heading, where the river began rising at midnight and rose at the rate of 1 ft. per hour until the peak was reached early in the morning. At 3:30 A. M. Mr. Hind and the writer left Yuma on the work train, reaching the Lower Heading about 5:15 A. M. and found three serious and distinct breaks within 100 yd., the first one being about 2 400 ft. from the south end of Hind Dam. In addition water was finding its way under the levee in about ninety other places, within the stretch where the water reached the toe of the levee, or about $\frac{3}{4}$ mile above and an equal distance below the dam. Mr. J. Calvert, General Foreman, had fully obeyed instructions, and when the water began to reach the toe of the levees at the lowest point, had commenced work with his force of about 75 men, doing all that seemed possible. The trouble was not that any one break could not have been easily handled, but that so many points of weakness were developed practically at the same time. Indeed, it is really remarkable that the situation got beyond control in only these three places.

A part of the general arrangements with the Inter-California Railroad was its use of the Hind Dam. On the south end of this dam the proposed alignment turned a small angle to the right, and it was planned to have the fill for the next 2 miles without any openings—constituting thus a spur levee to prevent any water which passed through the main levees from reaching the old channel of the break beyond the dam. Had this fill been ready, or had the first serious break been 500 ft. farther along, sand bag diking across the traverses and out into the brush to force the water to spread out and follow an old and well-defined swale which entered the Alamo 2 miles beyond, would have been easily possible. In either case, the damage would have been limited to losing less than 1 000 cu. yd. of levee section.

As it was, however, the water coming through the breaks filled the borrow-pits on the land side, overflowed the intervening traverses, and, as the land in general sloped westward, over-topped the last traverse by the channel of the break below the dam, and caused a rapid grade recession from there, following the borrow-pits through the nearest break. When Mr. Hind and the writer reached the scene, the first of the three breaks was beyond control, and the situation was hopeless.

By the time the grade recession had reached and passed through the break, the flood had crested, and the water had risen against the levee to a depth of about 4 ft. The water rushing through rapidly increased, and cut into the far side of the bank, and was deflected and began cutting into the land side of the levee. This soon breached the dike about 1 000 ft. from the end of the Hind Dam. This breach became the main break, and was rapidly widened and deepened until, within 24 hours, the old channel was again entirely dry and the river had been re-diverted into the Salton Sea.

The men of the grading outfit engaged on levee extension work 3 miles down the river were flooded out, and the steamer *Searchlight* was sent to relieve them. The re-diversion into the Salton Sink occurred so rapidly that the steamer was left grounded there in the old channel, and inasmuch as it was the only craft on the river not controlled by the contractors on the Laguna Weir, this was a serious matter.

The Southern Pacific Quits.

This disaster brought to the higher authorities of the Harriman Lines a thorough realization of the size of the great task of controlling

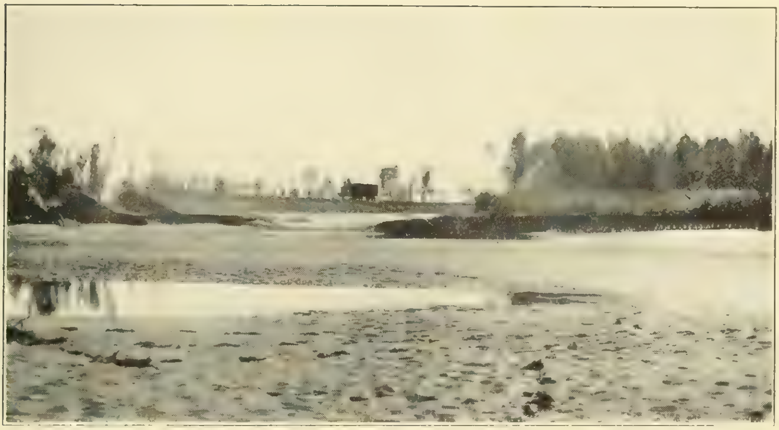


FIG. 1.—LEVEE FAILURES RESULTING IN SECOND BREAK, DECEMBER 7TH, 1906. NOTE THE SHORT LENGTH OF THE TWO GAPS.

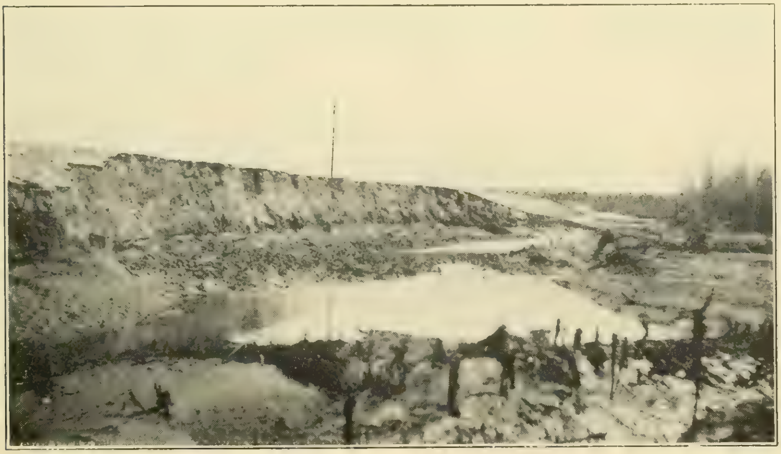


FIG. 2.—EFFECT OF FLOOD OF DECEMBER 7TH, 1906, ON LEVEE OF U. S. RECLAMATION SERVICE, OPPOSITE LOWER HEADING.

the Colorado. The imperative need of invulnerable levee construction for at least 10 miles along the river was made evident, and the difficulty and cost of building and maintaining such a system was emphasized. Entirely aside from the very great cost of bank protection work to prevent the breaching of levees through the side cutting of the banks, was the difficulty of building in such bad soil a line of defence which would be absolutely dependable.

The financial condition of the C. D. Co. and the Mexican Co., as just explained, was very bad, and, under the most favorable circumstances possible, the chances of the Harriman interests ever being able to get back very much of the moneys already advanced were extremely remote. In addition, however, it was apparent that an unusually efficient and expensive levee system would be required, the first and maintenance cost of which was too large a burden to undertake.

The stockholders of the irrigation properties notified the Southern Pacific management controlling them that the properties could not be expected to do such overflow protection work, and indeed should not pay more than a proportional part based on the total value of the property interests in jeopardy, especially in view of the immense amount of work which had already been done at its expense. Urging that the irrigation company had caused the menace (which may or may not be entirely the case) had not the slightest significance to the Southern Pacific interests, which were really the only ones with any funds, collateral, or equipment, and were in no possible sense responsible for any changes in physical conditions along the Colorado River, except to make them very much better than they otherwise would have been.

On the other hand, it was recognized that something would have to be done very quickly because the summer flood of 1907 would in all probability cause such grade recessions as to force a hurried exodus from Imperial Valley which would be without a parallel in history. The chances of such grade recession extending far enough to render the control of the river after that flood very much more difficult, were remote. The matter was made complex by the fact that all work had to be done in Mexico and practically all property interests in jeopardy were in America; and there were no provisions, State or National, to handle such a curious situation. Unless the river was turned and kept going to the Gulf, the Southern Pacific would suffer the loss of its traffic from the Imperial Valley and would have to change its line and build 100 miles of track, but, to obviate these losses would certainly not justify it in undertaking to control the river single-handed.

Accordingly, the people of Imperial Valley were notified that, while the Southern Pacific would be very glad to place such equipment and organization as it had along the river at the disposal of any party who wanted to proceed with the work, and would be willing to contribute toward the expenses thereof in proportion to the value of its interests as compared to all others in jeopardy, it would not advance additional funds without a definite arrangement for being reimbursed. Work on a roadbed following —100-ft. contour was ordered and rushed to completion. The cost of grading was very small, and such a line would preclude the possibility of the interruption of transcontinental traffic by the Salton Sea for at least 4 or 5 years, during which time a line lying entirely above sea level could be economically constructed.

On December 13th a mass meeting of the people of Imperial Valley was held in Imperial, and subscriptions for river control work, totaling $950 000 were made by various interests. These were the Imperial Valley Improvement Company (the practical successor of the Imperial Land Company) $100 000; the Holton Power Company, $100 000; the C. M. Co., $250 000, and the directors of the mutual water companies together a bond issue of $500 000. All these were made promising payment 90 days after the break should have been closed successfully, the railroad to assume all risk of the work.

While considering these subscriptions, it was urged in opposition that the mutual water companies might not be able legally to issue bonds or expend money for river protection work at all, or indeed that the people of the valley could raise money, except by individual subscription, for work to be done in Mexico. Requests were sent out in all directions, resulting in numerous civic and political bodies and authorities of the State wiring to President Roosevelt asking to have the United States Government act in the emergency. The President acted promptly, and as the result of telegraphic correspondence with Mr. Harriman, instructions to start work on the river were received on December 20th.

In the meantime the organization at Andrade and at the Lower Heading had been kept intact. The quarry was developed, sidings just across the border in Mexico were lengthened to 7 000 ft., and material and equipment of all possible kinds which might be needed were gathered in readiness to proceed whenever orders might be received.

SENATOR FLINT'S BILL.

Immediately after the holidays, Senator Frank C. Flint, of California, introduced a bill in the Senate providing for the appropriation of $2 000 000 to handle the situation. Under the provisions of this bill, whatever sum might be found just should be paid to the Southern Pacific Company for work then under way, and the remainder should be utilized to establish an irrigation project for Imperial Valley by the U. S. Reclamation Service. The idea was that the irrigation of American land in the Salton Basin and the regulation of the Colorado River were inseparably connected, and that as soon as the situation should be under control by the Southern Pacific Company, the entire matter should be turned over to the Reclamation Service for future handling. President Roosevelt, on January 12th, 1907, sent a special message to Congress severely criticising the promotors of the C. D. Co. and the management of the properties, and urging the passage of the Flint bill in order to relieve the settlers of Imperial Valley from the "injustice" they were enduring.

When the bill reached the House, Hon. S. C. Smith, Representative from the Eighth California Congressional District—in which Imperial Valley is located—opposed it, advising that he did so because of requests from his constituents in the valley. There can be no doubt that, with very few exceptions, the farmers in the valley objected to the bill, preferring the existing irrigation arrangements to those which would follow under the Reclamation Service,* and desiring governmental assistance in river protection work, and in that only. Largely due to Mr. Smith's efforts, the bill failed to pass.

CHANGE IN ORGANIZATION.

In spite of the opinions of visiting engineers, experience during the first closing left little doubt that there would be any particular difficulty in making the second closing without any brush mattress foundation. Even had such been deemed desirable and worth the delay in time, very little brush was available nearby because of the large quantity used for the first closing. It was felt that the work was standardized and consisted in throwing ordinary railroad trestles across the break and from them making rock fill dams in series. The levee construction work to be done, however, was very much of a problem in every way. Superintendent Hind was transferred to the levee reconstruction and extension, and Mr. Clarke, formerly Resident Engineer of the Tucson Division, Southern Pacific Company, came to the work as Superintendent of the second closing on December 20th, 1906.

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* Among the objections, the two most important were the probable increase in cost of water and the necessity for reducing individual holdings to probably 40 acres or less.

At the same time, an entire change in the accounting system was ordered, effective December 7th, the date of the break. Prior to that time the work had been done by the Mexican Co., with material and funds supplied by the C. D. Co., and the latter corporation from time to time borrowed money from the Southern Pacific Company. This was changed so that the Mexican Co. was furnished money by Epes Randolph, Agent of the Southern Pacific Company, and the C. D. Co. had nothing to do with the matter whatsoever. On the American side of the line, the operations were exclusively under the name of "Epes Randolph, Agent, S. P. Co." The railroad furnished supplies and material to him under the same arrangements and conditions as it had furnished them to the C. D. Co., namely, at a cost plus 10 per cent. One marked difference, however, occurred in making these charges, namely, that after January 1st all freight bills were rendered at traffic rates instead of at ½ cent per ton-mile, this being made necessary by the provision of the Interstate Commerce Commission which took effect at that time.

CLOSING THE SECOND BREAK.

The work of closing the second break was in several ways interesting. To begin with, the current struck where the south end of the Hind Dam had been, and was there deflected sharply, resulting in very serious erosion. Few people who saw the break at this stage believed it possible to hold this erosion from going entirely through the structure, but by unloading immense quantities of rip-rap, the fill was held, the water in front cutting to a depth of about 42 ft.

Two trestles were decided on and started, five pile-drivers being used, one at each end of each trestle and a floating machine in the

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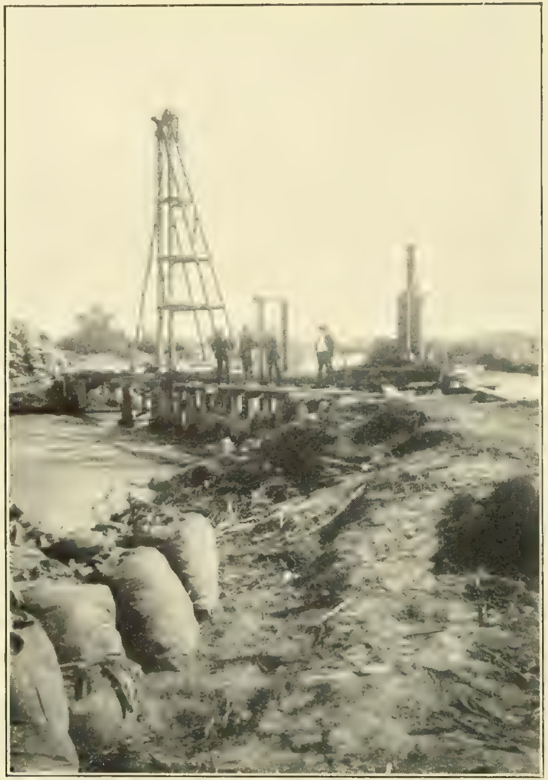

Fig. 1.—Closing the By-Pass Around Alamo Waste-Gate. Discharge, 2 500 Second-Feet. Final Head, 10 Feet.

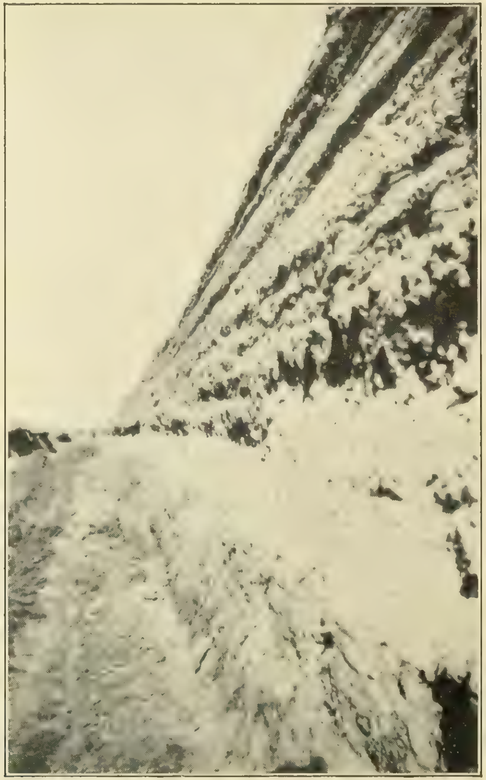

Fig. 2.—Reconstruction of Levees, Showing Muck-Ditch.

middle of the stream. These trestles had to be thrown in a curve concave up stream to connect with the levee on the south side, therefore the piles had to be driven in a very strong quartering current. The channel was narrowed and the bottom cut down to a maximum depth of 38 ft. In driving 90-ft. piles under these conditions, there was constant danger of overturning the driver and losing the machinery, therefore two complete pile-driving outfits were kept in reserve and two boats waited below the trestle to pick up any men who might be thrown overboard.

On December 28th one line of trestle was practically completed, when a flood, shown on Plate CIX (which, by the way, let the stranded steamer *Searchlight* get back up the river to the work), carrying unusual drift, tore out about one-third of it. Three times this occurred, resulting in the loss of a large quantity of bridge material. All this was obtained through Mr. R. H. Ingram, General Superintendent, Southern District, Southern Pacific Company, and the following telegram from him is interesting:

"Los Angeles, 1/14/07.

"H. T. C.—

"We have exhausted all available supply of piles in San Diego and Southern California. There is very little hope of getting any in Northern California. If you feel that you will need any more please let me know at once as we must make arrangements with the Atlantic System.*

"R. H. INGRAM."

On January 26th, 1907, the first trestle was finished for the fourth time, all stringers were in place, and the track was two-thirds laid. In the second trestle, 50 ft. above the first, seventeen bents remained to be driven. The fill on the south, connecting the trestle with the levee, was 60% completed. Stored on the branch line in Mexico and the United States there were 175 "battleships" of rock, loaded at the quarry of the C. D. Co. by steam shovels, and 100 flatcars of large rock from the distant quarries. At each end of the dam, ½ mile of the levees had been reconstructed, and 1½ miles more opened up, while there were 1 100 men and 1 000 head of stock engaged at Andrade and on the river.

On January 27th, the first trestle was completed, and dumping rock from it began at 5 P. M. By daylight 145 "battleships," containing

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* The lines from New Orleans to El Paso.

6 600 cu. yd. of rock had been unloaded as another flood from the Gila began arriving, but it caused little trouble. On February 10th at 11 P. M. the second break was closed, and all the water was again going down the old channel.

The following materials were used in the second closing:

4 000 ft. of railroad trestle—of this, 1 800 ft. were carried away by floods before either trestle could be completed or any rock could be dumped. When rock dumping began, no more trestle was lost; the final result was two trestles, 50 ft. apart, and each 1 100 ft. long, or 2 200 ft. of trestle.
16 000 ft. of 8 by 17-in. Oregon pine stringers—8 000 ft. of these were removed.
1 200 piles.
45 000 cu. yd. of earth placed by teams—making 960 ft. of earth dam to connect with the levee, 31 000 cu. yd. being placed by February 2d.
2 157 car loads, or 55 000 cu. yd., of rock used prior to actually closing off the water.
221 car loads, or 7 735 cu. yd., of gravel.
203 " " " 8 840 " " " clay.

The discharge of the river when work began on December 20th, 1906, was 12 500 sec-ft.

Dec 31st	48 900	sec-ft.
Jan. 7th	15 200	"
Jan. 12th	44 300	"
Jan. 18th	16 300	"
Jan. 20th	33 400	"
Jan. 27th (when first rock dumping began)	13 800	"
Feb. 3d	31 300*	"
Feb. 7th	17 700	"
Feb. 11th	20 800	"

After the break was closed, 956 car loads, or 38 240 cu. yd., of clay and 873 car loads, or 33 555 cu. yd., of gravel were used to complete the Hind-Clarke Dam. The rate of dumping rock, etc., is shown by Table 14.

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* 4 300 sec-ft. down the old channel.

PLATE CXXI.
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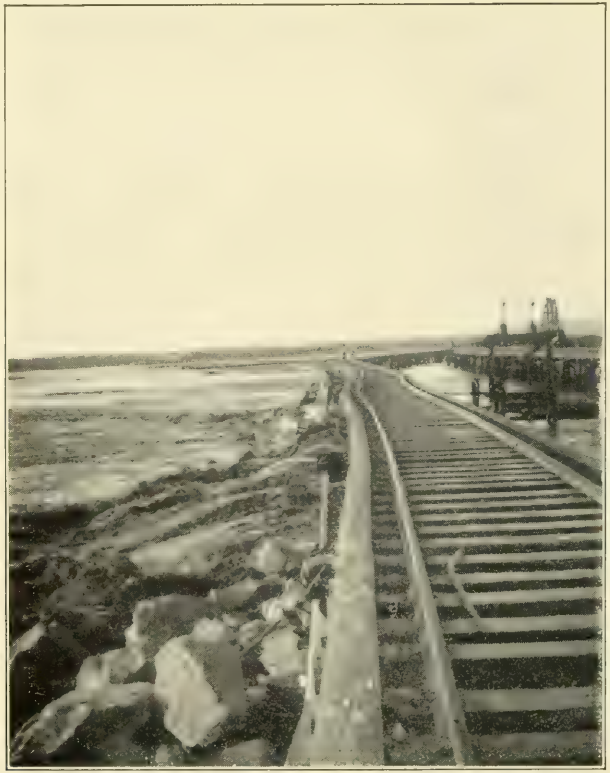

FIG. 1.—KINK IN LOWER TRESTLE CAUSED BY DRIFT BREACHING AND TAKING OUT FOUR BENTS OF UPPER TRESTLE.

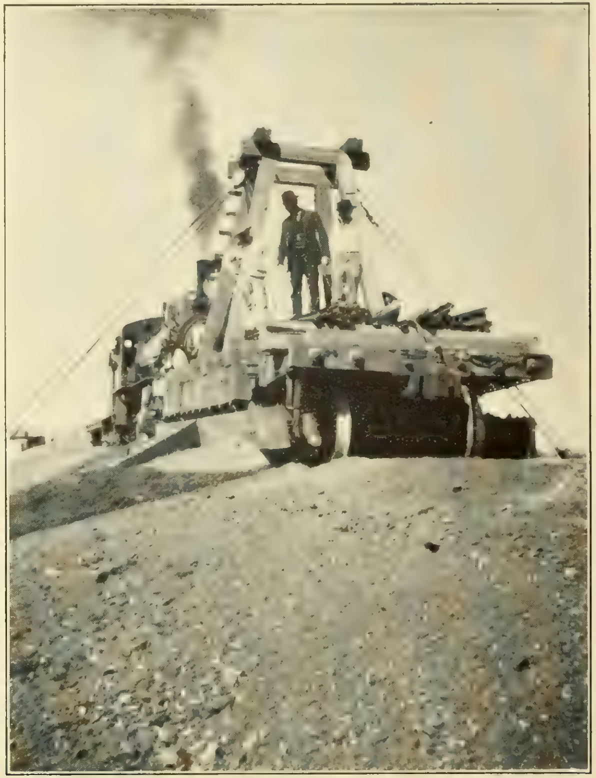

FIG. 2.—GRAVEL SPREADER IN OPERATION.

TABLE 14.—CAR LOADS OF MATERIAL.

	"Battle-ship."	Flatcar.	Clay.	Gravel.
January 27th to February 2d..................	606	501	8	15
February 3d to 9th..........................	489	385	58	140
February 10th to 10th midnight..............	85	91	38	28
	1 180	977	104	173
February 11th to 15th........................	323	77	99	48
	1 503	1 054	203	221

The water was shut off on February 10th at 11 P. M. and the flatcar rock then on hand and *en route* was unloaded in order to release the cars, the rock from Andrade being used until the 18th in raising the dam hurriedly to protect it against possible floods. The total number of car loads of material used in the closing and in the finishing up of the Clarke Dam were:

"Battleship."	Flatcar.	Clay.	Gravel.
1 490	1 182	784	873

During the entire operations subsequent to the second break, including finishing up the Hind-Clarke Dam complete, but exclusive of the rip-rap to hold the grade before the completion of the trestle over the break on January 27th, the following car loads of material were used:

"Battleship."	Flatcar.	Clay.	Gravel.
1 517	1 240	956	2 052

The clay pit was closed on March 3d, and the Hind-Clarke Dam was finished, except for the final surfacing with the spreaders, on March 15th.

Two steam shovels, and part of the time three (not including the one in the Mammoth gravel pit) were engaged from September, 1906, to May, 1907, at $7.50 per day, prior to January 1st, 1907, and at $12.50 thereafter. During the period, there were from 1 to 12 locomotives, at the following rates:

American, light....................	$ 8.00	per day.
Moguls..........................	10.00	"
Consolidation......................	12.00	"
Car pile-drivers, working 40 days at..	10.00	"
Donkey engines....................	1.50	"
Skid-drivers, complete.............	2.50	"

TABLE 15.—SOUTHERN PACIFIC EQUIPMENT USED ON RIVER, FROM DECEMBER, 1906, TO JULY, 1907, EXPRESSED IN CAR-DAYS.

Month.	Ballast cars, at 25 cents per day.	Steel side dump cars at 50 cents per day.	Cabooses, at 50 cents per day.	Water cars, at 50 cents per day.	Outfit cars, at 30 cents per day.	Home freight car detention (box and flat), at 15 cents per day.	Foreign freight equipment detention.
December, 1906...	595	3 271	80	141	42	371	306
January, 1907....	690	4 972	30	174	....	675	600
February, 1907...	219	4 609	15	153	....	47	78
March, 1907.......	54	5 565	27	321	....	47	71
April, 1907........	....	5 255	4	323	....	28	2
May, 1907..........	2	4 792	9	440	....	17	2
June, 1907.........	....	2 635	53	264	....	32	....
July, 1907..........	....	1 336	12	24	....	....	....
Totals	1 560	32 435	230	1 840	42	1 217	1 059

The Clarke Dam extends from the south end of the Hind Dam across the second break to the levees on the south. These two dams, consequently, constitute one continuous structure, which is known as the Hind-Clarke Dam.

RESULTS OF EXPERIENCE IN CONSTRUCTING THE HIND-CLARKE DAM.

The experience obtained in making these two closings, according to the methods used, afforded some information regarding work of this class which is believed to be entirely unique and in some respects unexpected. In the first place, it was shown that the brush mattress bottom protection is not only unnecessary, but adds to the cost, both in time and money, provided rock is thrown in at a reasonably rapid rate. In discussing the possibility of handling the situation along the lines decided on, the opinion was freely expressed that the rapid current would carry smaller rocks indefinite distances down stream, and that the larger ones would quickly settle into the soft, water-soaked, alluvial soil to indeterminate but very great depths. As a matter of fact, a relatively small quantity of "battleship" rock sufficed to blanket the bottom of the stream with a mattress of rock which fulfilled essentially the same function as a mattress of brush.

In this type of construction it is desirable to have rock of various sizes, such as obtained by blasting large quantities in the quarry and loading with a steam shovel. Large stones (from 1 to 7 or 8 tons), which can be loaded on flatcars only with derricks, are effective, but

PLATE CXXII.
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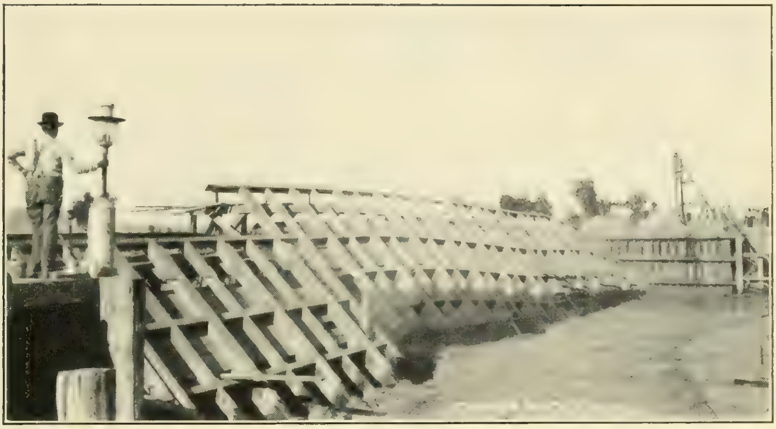


FIG. 1.—FAILURE OF ROCKWOOD GATE, OCTOBER 11TH, 1906.

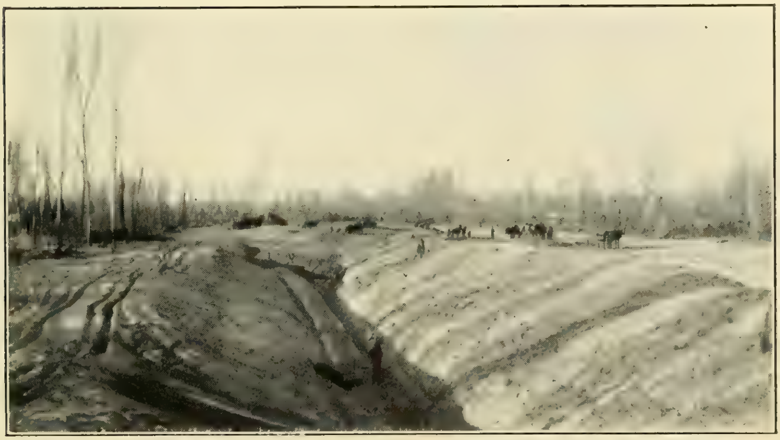


FIG. 2.—MUCK-DITCH CONSTRUCTION IN LEVEE EXTENSION WORK, 1907.

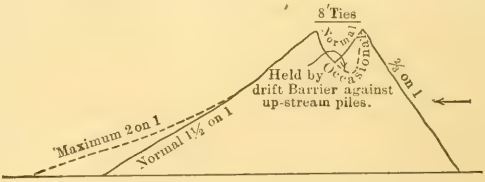
not absolutely necessary in raising short sections where, through carelessness or a little unexpected settling, an unusual quantity of water is going over a low place in the dam with consequent menacing velocity. Such large rocks were unloaded by a great number of men using pinch-bars, and, to prevent upsetting, the cars were chained to the stringers when unloading especially heavy rocks. One man was killed during each closing by going overboard with a large rock, and these were the only serious accidents. No equipment was lost during either closing.

Two trestles were used in both cases. These were 30 ft. apart in the Hind Dam, and 50 ft. apart in the Clarke Dam, the idea being that the current would prevent building a rock mattress extending far enough up stream by merely dumping rock from the trestle on which the closing was made. Careful examination of the resulting cross-section, when the water was shut off the first time, seemed to indicate pretty clearly that it was a needless precaution to have two trestles for final heads of 14 ft. or less. As there was to be no mattress in the second closing, it was decided to use two trestles, in order to take no avoidable chances. Everything worked so well that it seemed safe to do a little experimenting, and, practically speaking, the second break was closed from the lower trestle alone.

In both cases the fills at both ends were kept well above the possibility of being overtopped, and of uniform heights across the remaining length. Train loads extending entirely over the trestles were unloaded most of the time; but short sections of the fill which were low were promptly filled in, and great care was exercised to distribute the overpour evenly. Once, in the building of each of these structures, a local settlement occurred, resulting of course, in large quantities of water going over the relatively short lowered section. The same experience was had in making the upper coffer-dam wall for completing the gap in the Laguna Weir. The construction of a rock fill barrier dam was regarded as impracticable by engineers, because of just such occurrences surely breaching the barrier hopelessly. In point of fact, continued dumping of even small rock soon stops such so-called breaks, although that results in the waste of much material.

The chief difficulty is caused by drift in the stream being caught by the trestle. Theoretically, such drift should be very easily broken up and carried to the bottom by dumping rock. In practice, however, there is difficulty in keeping drift accumulations from seriously threatening the trestle. In Fig. 1, Plate CXXI, a very sharp kink will be observed which is due to drift accumulations throwing the entire trestle out of line. Two or three bents were taken out of the upper trestle from this cause.

It was found that a cross-section of the dam under the trestle is about as shown in Fig. 22, so that it is the inevitable little breaks and slides, rather than actual settling, which occurs in such cases. Local readjustments or settlings were easily handled with an estimated quantity of 100 sec-ft. per lin. ft. of dam going over the rock fill. How much more could be handled safely with the rock available is not known. The writer would say that experience along the Colorado River would not justify using the rock fill barrier dam method for quantities in excess of half that flow, on an average, although possibly much greater rates of discharge over such a structure might be safe. The quantity which went over the 680-ft. crest was 27 000 sec-ft.



RESULTING SECTION OF ROCK FILL DAMS MADE DURING FIRST AND SECOND CLOSINGS

FIG. 22.

The total length of rock fill dam used in the trestle was 1 125 ft., and the water was allowed to pour over 680 ft. of it; the trestle consisted of 4-pile bents, all piling vertical, 15-ft. spacing between bents, average penetration of piling about 18 ft. The total head, or the difference in water surface above and below the dam, was 12.45 ft., all developed in place in 13 days and 5 hours.

By way of comparison, the building of the upper and lower sides of the coffer-dam within which the central or channel portion of the Laguna Weir was completed is most interesting. One line of trestles, 740 ft. long, was thrown across the stream just above the upper edge of the weir, and another trestle, 728 ft. long, below the lower edge, the trestles being about 400 ft. apart. From these trestles rock fills were built up, and all the water in the river was forced through the sluice-gates at the ends of the weir, the Arizona sluice-way being 2 700 ft. distant and the California sluice-way 1 500 ft. There were well-developed quarries at each end of the weir, and the haul was from 1 500 to 3 500 ft. The following equipment was used:

One 2½-cu. yd. Atlantic type steam shovel (in California quarries).
One 2½-cu. yd. Marion steam shovel (also in California quarries).
Seven 12½-in. American steam hoists, mostly in the Arizona quarries.
Six 18-ton standard gauge Davenport locomotives.
Fifty 6-cu. yd. dump cars.
Eighteen 5-cu. yd. steel dump cars.
Fifty flatcars.

By December 10th, openings to and from the sluice-ways were completed, and the rock fills were advanced until the head was 2.8 ft. On December 19th, the head had been increased to 6.9 ft., of which about 3.5 ft. were on the lower rock fill, while 8 500 sec-ft. were going over these and 3 200 sec-ft. through the sluice-ways. On account of a reported flood, due to heavy rains on the Little Colorado water-shed, work was concentrated on the upper coffer-dam, and by noon of December 21st the gap was closed and the river—9 950 sec-ft.—was turned through the sluice-ways, the head being 3.5 ft. on the lower and 5.4 ft. on the upper fill, or a total head of 8.9 ft.

The river began to rise 30 hours later, and crested at daybreak on the 23d, the discharge being 35 250 sec-ft. Water passed over the entire length—4 200 ft.—of the completed dam, 3.2 ft. deep, but lacked 10 in. of reaching the general level of the upper rock fill. The lower coffer-dam was injured considerably by water running lengthwise of the dam on the down-stream side, so that the upper rock fill stood all the head, which reached a maximum of 10.1 ft. Two weeks later the damage sustained by the railroad tracks on top of the finished parts of the structure had been repaired, the lower coffer-dam had been completed above the danger line, and work had commenced on the 650 ft. of gap in the main structure within the coffer-dam.

About 600 men were engaged on the closing, working in two 10-hour shifts. The total cost of turning the river through the end sluice-gates and constructing the coffer-dam is given as $86 072; the total rock used was 59 750 cu. yd. of excavation, making 82 800 cu. yd. in the rock fill. No lives and no equipment were lost, and the time required after beginning to dump rock was about 2 weeks.

The total cost of the rock work in the fills, including trestles, quarrying, train service, superintendence, depreciation, and all overhead charges of the project was $1.04 per cu. yd., of which 45%, or $38 720, was for excavation, Class 1 (quarrying solid rock).

Completing the Clarke Dam.

The Clarke Dam was rendered impervious by dumping Mammoth pit gravel and clay from both trestles. No attempt was made to puddle or settle the material by hydraulicking, as was done with the Hind Dam. Small local settlements occurred from time to time for a year after the dam was completed, but nothing disquieting in any way. Imperviousness was very quickly obtained, indeed, long before the structure was raised to grade and widened to its proper dimensions.

In constructing the Hind Dam, every effort was made to hurry the work, and the stringers were not taken out. With the Clarke Dam, all stringers were removed, the tracks were raised and narrowed to 13 ft. from center to center, and the top and sides were finished off with the gravel spreader used on the levee work, leaving the finished structure as shown on Plate CXIII and Fig. 1, Plate CXXIV.

Spur Levee.—A spur levee, 8 700 ft. long, was built, starting at the elevation of the top of the Hind-Clarke Dam (124 ft.), and with an initial descending grade of 0.5 per cent. The purpose of this levee is to prevent water from any break in the main levee south of the Hind-Clarke Dam from getting into the old dry channel below, as happened when the second break occurred. It is intended to hold such water back and make it spread over the low country in a sheet. This levee, which was decided on, but not started, before the second break, is located along an old overflow channel slightly higher than the country on either side, and where test-pits showed need for little muck-ditching. Arrangements were made later with the Inter-California Railroad to change its alignment to use this spur levee and the Hind-Clarke Dam, and it was thus extended by this railroad grade for 4 miles without any opening.

Changes in Staff.

The success of the Hind-Clarke Dam being assured, arrangements were concluded whereby F. C. Herrmann, M. Am. Soc. C. E., on February 1st, 1907, became Assistant Chief Engineer of both the C. D. and Mexican Cos., particularly for the purpose of making surveys and estimates for reconstructing and extending the canal system in Imperial Valley. About March 1st, the Clarke Dam being then well advanced, Mr. Clarke was transferred to the valley and appointed Superintendent of Construction of both companies, Superintendent Hind remaining in charge of all operations along the river until they were finished, when he was transferred to the Harriman Lines in Mexico, on August 1st, 1907. On May 1st, Mr. Clarke returned to the railroad as Resident Engineer of the Coast Division. Nearly two years later he came back to the valley as Superintendent of Imperial Water Company No. 1, and early in January, 1910, was appointed by the Receiver of the C. D. Co. as Assistant General Manager and Chief Engineer, which position he resigned in April, 1911. The writer relinquished the title of Chief Engineer in both companies in July, 1908, and issued circulars advancing Mr. Herrmann to the positions which he held until he left the companies, in March, 1910, after the appointment of a receiver. His successor in the Mexican Co., and its present Chief Engineer, is Mr. C. N. Perry, who first came to the valley with Mr. Rockwood in 1892, and was Resident Engineer of both companies from October, 1901, to August, 1906, and so was in immediate charge of most of the existing canal construction in Imperial Valley. Since April, 1911, Mr. J. C. Allison has been Chief Engineer of the C. D. Co.

Levee Reconstruction.

On December 20th, 1906, reconstruction on the existing levees was begun by tearing away the land side of the levee and excavating a continuous muck-ditch as deep as the test-pits indicated to be necessary. The usual location of a muck-ditch is under the center of the levee section, but, in reconstruction work, this was not practicable, and besides, there were several reasons for location nearer the land toe, which will be mentioned later. The excavation was made as narrow as possible with the use of 4-horse Fresno scrapers, and it was found that the walls, not only of the natural soil, but of the recently constructed levee section, stood practically vertical without any caving. (Fig. 2, Plate CXX.) The muck-ditch was excavated 1 ft. lower than the lowest layer of cracked adobe soil lying above the permanent water-table, and was refilled with the material removed, care being taken to keep out roots and clods of adobe exceeding 3 or 4 in. in greatest dimension. When the muck-ditch was completed, the land side of the levee was replaced to the slope of 3 to 1, instead of 2 to 1, as originally built. This work was started on force account, but was soon changed to a yardage basis, on the following schedule:

Levee section removed and replaced in embankment, 12 cents per cu. yd.

Muck-ditch excavation and refill, 17½ cents per cu. yd.

Reinforcing levee section, 19 cents per cu. yd.

The total earth handled was 199 000 cu. yd.

Levee Extension.—At the same time, surveys were commenced for extensions of the levee to the south. From Mile 7 the original alignment continued closely paralleling the river, and here all clearing had been done for 2 miles, and about 20% of the fill had been made. At the south end the flood caused three breaks, close together, through almost completed levee section. These breaks were due to bad material, that is, adobe which in working had broken up into small, hard clods. Directly across the river, similar breaks had occurred in the levee of the Yuma Project. In addition, the river during this flood showed a marked tendency to cut into the west bank immediately opposite.

The surveying party found that the most suitable soil and the highest ground, west of the river bank itself, lay along the Paredones overflow channel, which turned away more than a safe distance from the river. This channel was followed beyond the undergrowth to open country, and a hurried reconnaissance showed that at some future time, by building approximately 20 miles of levee, most of it relatively low, connection could be made with the mountain chain on the west side of the delta at Cerro Prieto.

It was felt that the work now in progress was not merely to prevent flood-waters from quickly getting around the end of the Hind-Clarke Dam, but that very soon a system of dikes constituting a continuous line of defence for the Imperial Valley must be provided. President Roosevelt had not requested or authorized Mr. Harriman to construct anything so elaborate, but only what would form a protection for a few years at most, or until suitable permanent arrangements could be made to control the river properly. Such levees as were to be built, however, obviously should be constructed with a view to being incorporated in their entirety in the final scheme.

Two plans for keeping the overflow waters of the Colorado from getting into the Salton Sea are at once seen to be better than any others. One is a levee line along the Paredones ridge and north of Volcano Lake to Cerro Prieto, and the other is a line of levees parallel to the river practically to tide-water. These two plans are shown in Fig. 4. The first would protect all American interests and all that territory in Mexico lying to the north and west; the second would also protect the very large area lying between. This additional area is the property of the C. M. Co., and is in an extremely good location for irrigation from the Colorado. The C. M. Co., on being approached regarding the matter, thought that its present interests would be best served by the northern line of defence, which thus precluded the possibility of financial assistance from that company in giving additional protection, and the matter resolved itself into a decision as to which of the two lines could be built and maintained at least cost. The instrumental data regarding the region were insufficient to decide between the two possibilities, and, incidentally, the same condition of affairs unfortunately exists to-day. However, something had to be done, and at once. Based solely on careful reconnaissance, the northern line of levees was decided on, and the portion to be immediately built was located to a point about 10 miles below the Hind-Clarke Dam, this being enough to prevent water from getting around into the Alamo channel during flood stages. Aside from the desire to do only what was absolutely required and could certainly be finished before the summer flood, it was felt that the officials of the Mexican and American Governments should have the greatest freedom in determining on future work for controlling the river.

The grade was determined from existing high-water marks along the line of the levee, checked by high-water marks along the line of the river; and several miles at the lower end has a grade of 3 ft. per mile. The cross-section decided on was a top width of 10 ft. and slopes of 3 to 1 on each side.

Muck-Ditches.—The Yuma Project, U. S. Reclamation Service, loaned one of its engineering corps, the method being to grant leave of absence to the members and have them carried on the payrolls of the Mexican Co. This corps was in charge of Mr. C. W. Ozias, Assistant Engineer, and was assigned to levee location work. Mr. Ozias was instructed to make tests for determining the time at which efficient compression of adobe soil would take place with distributed loads, as under a levee when immersed in water. For these tests some hard chunks of adobe were taken from the muck-ditch excavation, 2 ft. below the surface at Station 178, and placed in a box 1 ft. in each dimension, in as nearly natural condition as possible, and kept under a continuous pressure of 500 lb. per sq. ft. At the end of 1 hour ½ cu. ft. of water was added, part of which leaked out. Compression started rapidly, and continued for 1 hour, due to the chunks being pressed closely together in the box, and slower compression started at the end of this time. The compression continually decreased until the 40th hour, when no more movement was noticeable on the scale beam. The mass was then removed from the box and found to be plastic and pressed together so that it contained no voids. From this it appeared that efficient compression under a load of 500 lb. per sq. ft.

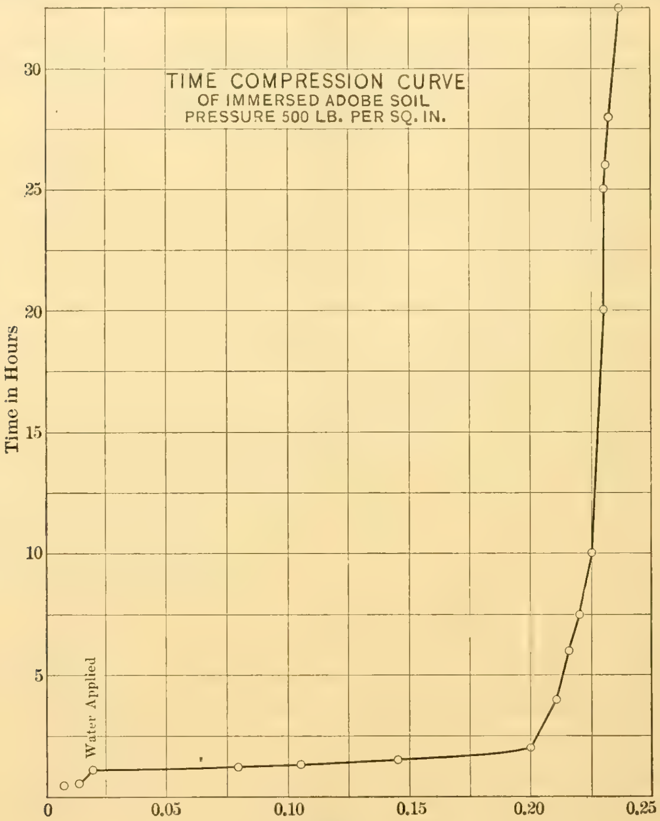


FIG. 23.

starts at the end of an immersion of about 3 hours, and continues indefinitely until all the voids close. This is why borders, canal banks, levees, etc., in that region soon become impervious if breaks can be prevented during that period. It is the inability to prevent breaks over a long line which renders a muck-ditch of some form practically necessary.

The results of this experiment suggested dampening the slickens under the levee section enough to have the voids in it closed by compression due to the weight of the levee section. Such wetting could be brought about by digging a trench along one or both toes of the levee and pumping water into it, and would save the large cost of muck-ditch construction. As this levee line was too vitally important for such an innovation, it was decided to use a muck-ditch 6 ft. wide on the bottom and having side slopes of 2 to 1, the excavation to extend at least 1 ft. below the lowest layer of cracked adobe soil above the water-table. Test-pits were dug every 200 ft. to determine the necessary depth.

The muck-ditch, however, was located under the land toe of the levee, as shown in Fig. 19, because it was not deemed desirable to prevent water from getting under the levee, but, on the other hand, to allow water to go under it as far as possible and still certainly hold it back with the muck-ditch. In this way the cracked adobe layers under the levee section would become impervious as a whole in the minimum time after the water came as high as the toe of the levee.

The muck-ditch, except for two short stretches, was filled with the soil taken from it, only a few places being found in the 17 miles constructed where bad material occurred in such masses as to render it at all difficult to mix the adobe clods with satisfactory material taken out of the excavation.

Borrow-Pits.—Borrow-pits were located on the land side, leaving a berm of 40 ft. and traverses 20 ft. wide at intervals of 250 ft. It was specified that borrow-pits be left in workmanlike condition, with a maximum depth of 2½ ft. on the side nearest the levees and 4 ft. on the farther side. The reasons for borrow-pits on the land side have already been given. The occurrence of the second break was not considered to indicate any good reason for change in this particular.

Contracts and Contractors.—All levee extension work was done on a yardage basis, a contract being let to W. K. Peasley and Company, of

Los Angeles, for 18½ cents per cu. yd., for the entire levee cross-section, including the muck-ditch, and 10 cents per cu. yd. for refilling the muck-ditch section. The price for clearing and grubbing was $200 per mile. The contractor assumed all risk of expenses due to delays caused by flood, and the company paid all customs charges at the Boundary Line.

The Yuma Project, U. S. Reclamation Service, permitted the use of 120 head of its rented stock in order to assist in completing the work before the summer flood. This outfit worked under the usual regulations of the Reclamation Service, on a rental basis, and the levee contractor put it on the work and paid the Mexican Co. what the latter paid. The Reclamation Service engineers advise that levee construction on the Yuma Project has been found to cost much less than Mr. Peasley's contract, but, for some reason or other, the levee contractor and the company's timekeepers, who checked the work, show that the contractor's price for the work done by this grading outfit on this job was less than its cost. The great hurry had a marked effect on the expense to the contractor, however. At any rate, the writer had an opportunity to examine the contractor's books later, and found that his profit on this job, with proper overhead and equipment deterioration charges, was 17.3%, and none of the possible delays due to floods, etc., occurred.

All work was very carefully inspected by an unusually large corps of men, and every precaution was taken to prevent any roots or rubbish from getting into muck-ditches or fills, and to see that all muck-ditch construction was carried to the depths ordered.

Railroad Track.—When completed, all levees, both as reconstructed and extended, were laid with a railroad track consisting of new 6 by 8-in. Oregon pine ties 8 ft. long and good old 56-lb. relaying steel obtained from the Southern Pacific Company. This was done partly because of the great advantage in maintenance work in future and partly to distribute a blanketing of Mammoth pit gravel.

On the completed work 15 miles of track were laid on the main levee, 1½ miles on the spur levee, 5¾ miles from Hanlon's Junction to the Lower Heading, 2.6 miles of sidings, quarry tracks, etc., in California, and 2.7 miles of sidings and double track over the Hind-Clarke Dam in Mexico. No part of this track has been taken up, but the main

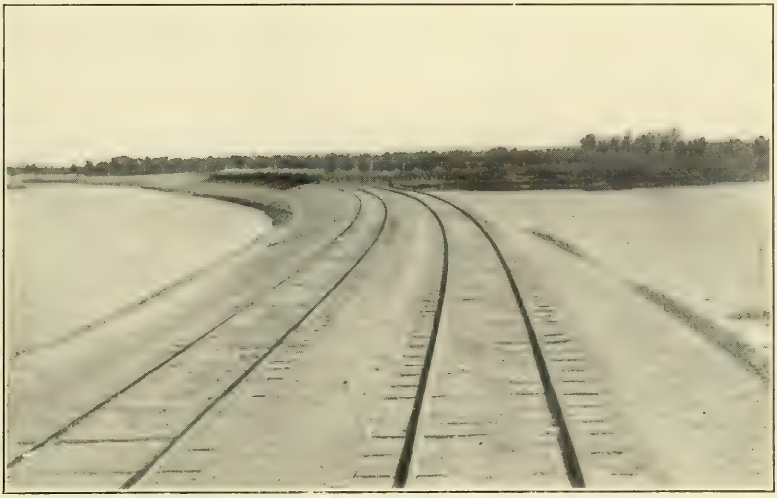


Fig. 1.—South End of Hind-Clarke Dam, Showing Location of Second Closing.

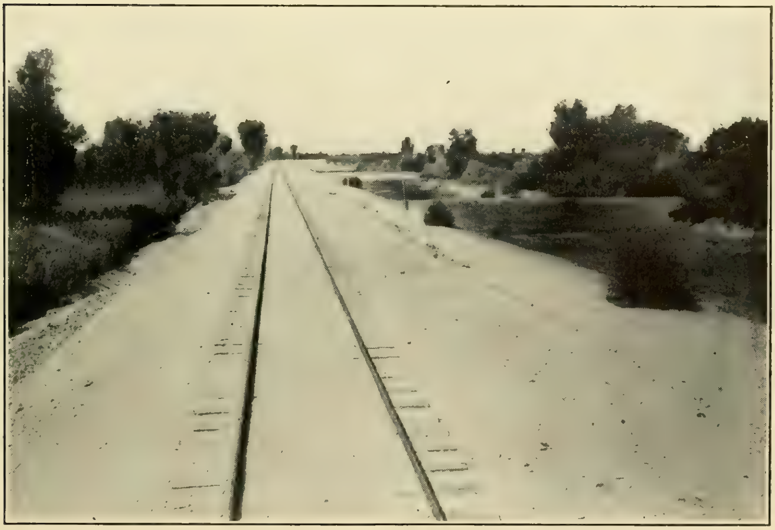


Fig. 2.—Typical Section of Completed Levee with Land-Side Borrow-Pits.

line and sidings between Hanlon's Junction and the end of the spur levee have been sold to the Inter-California Railroad.

Gravel Blanketing.—Vegetation, springing up like mushrooms on fills in the region, very soon precludes any possibility of inspection. The roots also attract burrowing animals. Furthermore, the danger of erosion on the water face by swift currents due to the fall of 3 ft. per mile made it exceedingly desirable to provide a better surface for the eddy currents. For these reasons all levees were blanketed on the top and both sides with a 15-in. layer of gravel from the Mammoth gravel pit, which, as has been said, supplies a cementing material which packs into an almost impermeable surface. It was practically impossible—and would have cost more money—to have blanketed the water face only or to have put a greater depth on it than on the land side, because all the gravel was hauled in "battleships" which dumped equal quantities of material on each side. Ordinarily, two cuts of cars were unloaded, a considerable portion of the first being used on the top and to surface the track. The remainder was spread evenly over the two slopes of the levee with a home-made spreader devised and constructed by Superintendent Hind at a total cost of $300. Its construction is shown on Fig. 24 and Fig. 2, Plate CXXI. With this the gravel was spread in an extraordinarily workmanlike manner at a cost of 0.1 cent per cu. yd. It worked in either direction, and the ordinary process was to have one cut of gravel dumped along from 3 000 to 6 000 ft. of levee, and have a locomotive take the spreader on two round trips, the usual speed being from 10 to 12 miles per hour.

Very much more permanent and expensive blanketing of levees is to be found on the Sacramento River, California. In Reclamation District 307, near Lisbon, about 15 miles below Sacramento, a length of a little less than 3 miles of levee has recently been completed. This keeps out the back waters, in which there is little current, but, on account of the width, the wave action is relatively severe. The blanketing was begun about July 1st, and finished about December 1st, 1911, and consists of 700 000 sq. ft. of reinforced concrete 4 in. thick. (Fig. 2, Plate CXXV.) The reinforcement was a No. 10 gauge wire, 6 by 6-in. mesh, known as the Clinton Electrically Welded Fabric. The concrete was a 1:2:5 mixture, with rock brought by train from Oroville to Sacramento and thence by barge to the work, and cost there about $1.50 per cu. yd. The Reclamation District furnished the cement and reinforcing material, and the contractors, Richard Keating and Sons, of San Francisco, did all the other work. Mr. P. N. Ashley, County Surveyor of Yolo County, Woodland, was engineer. This covering cost 13 cents per sq. ft., or a total of about $94 000, or approximately $32 000 per mile. The average height of the levee was 22 ft.

TABLE 16.—STATEMENT OF CHARGES ON ACCOUNT OF OPERATION OF MAMMOTH GRAVEL PIT, FROM OCTOBER 15TH, 1906, TO JULY 15TH, 1907, INCLUSIVE.

Labor of gangs in pit getting out gravel		$23 312.46
Use of tools, 2% on above labor		466.25
Wages of trainmen in pit		3 108.91
Wages of enginemen in pit		2 111.65
Wages of operators, etc., at pit		897.19
Rental of engine in pit		2 202.50
Rental of steam shovel in pit		2 457.50
Fuel furnished for pit engine		4 495.14
Fuel furnished for steam shovel		1 594.41
Material purchased for pit engine repair	$184.63	
Material purchased for steam shovel	548.90	
Miscellaneous supplies	6 890.88	
Miscellaneous pit engine supplies	237.98	
		7 862.39
On store department expense, 5%		393.10
Shop repairs to steam shovel		727.19
On shop expense, 10%		72.72
Freight on material shipped to pit		6 345.86
Miscellaneous credit		*119.74*
Total		$55 927.53

TABLE 17.—CARLOADS OF GRAVEL SHIPPED.

Month.	To California Development Company.	To Epes Randolph, Agent, S. P. Co.	To Southern Pacific Company.	Totals.
1906.				
October	357	.....	....	357
November	1 171	.....	18	1 189
December	.....	593	718	1 311
1907.				
January	.....	479	644	1 123
February	.....	756	726	1 482
March	.....	1 849	300	2 149
April	.....	2 178	114	2 292
May	.....	2 032	233	2 263
June	.....	1 082	527	1 609
July	.....	239	59	298
Total	1 528	9 206	3 339	14 073

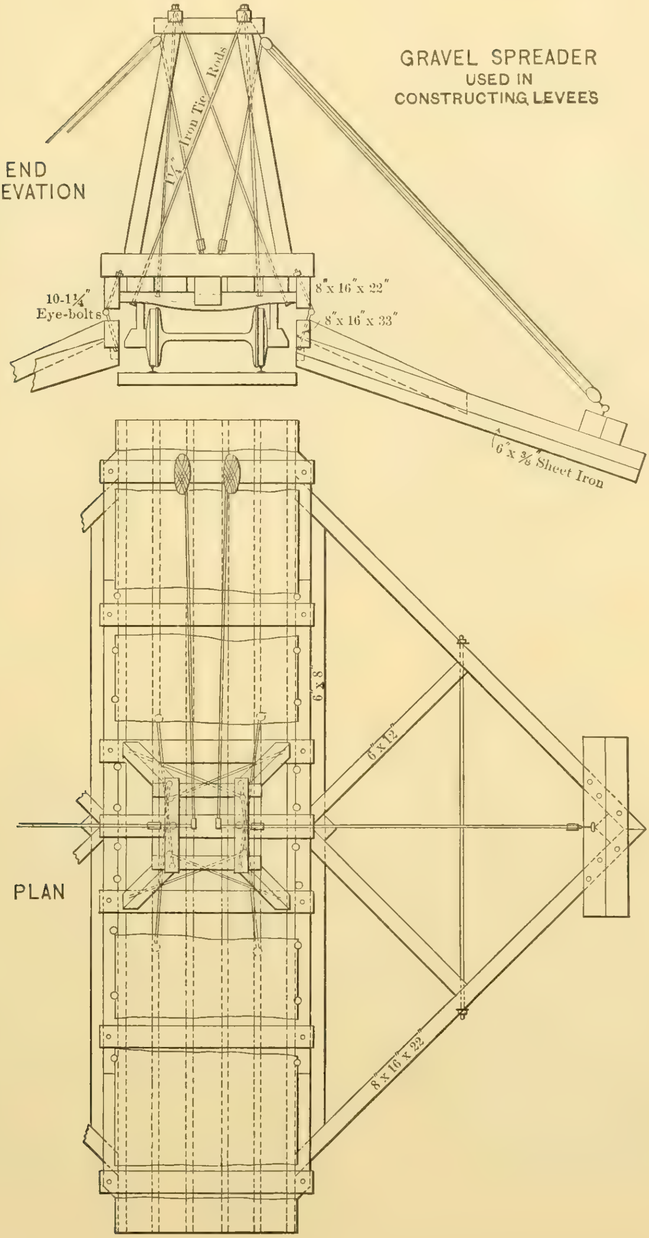

GRAVEL SPREADER
USED IN
CONSTRUCTING LEVEES
END
ELEVATION
1¼" Iron Tie Rods
10-1¼" Eye-bolts
8"x 16"x 22"
8"x 16"x 33"
6"x ⅜" Sheet Iron
PLAN
6"x 8"
6"x 12"
8"x 16"x 22"

Fig. 24.

The following is a detail of charges for royalty to Epes Randolph, Agent, S. P. Co.:

Value of tracks in Mammoth gravel pit, property of S. P. Co.		$16 832.00	
Interest on $16 832.00 for 1 month at 6% per annum	$75.74		
Depreciation on $16 832.00 for 1 month at 5% per annum	70.13		
	$145.87		
Interest from December 1st, 1906, to July 15th, 1907, 7½ months		1 094.03	
Total number of cars removed by Epes Randolph, Agent, S. P. Co., 9 206, or	$0.11883		interest per car.
Charge for gravel, 1 cent per cu. yd., 30 cu. yd. per car, or	0.30		royalty per car
Total royalty charged per car	$0.41883		

Average cost per car, $55 927.53 divided by 14 073 = $3.9741014 per car.

In blanketing the levees 5 285 carloads, or 185 000 cu. yd., were used. Of this, 4 803 carloads, or 168 000 cu. yd., were used on the 15 miles of main levees, or 16 800 cu. yd. per mile, and 482 carloads, or 17 000 cu. yd., on the 1.6 miles of spur levee, or 10 633 cu. yd. per mile.

Wing Levees.—In addition to blanketing the levees with cementing gravel, wing levees of gravel were built out into the brush, at intervals of about 400 ft. Their purpose is to check the flow of water in the V-shaped section between the trees along the near toe and the water face of the levee. Brush abatis work was not considered sufficiently permanent.

Telephone Line.—A two-wire, metallic-circuit, telephone line was constructed along the land toe of the levee after the gravel blanketing was finished. The location was unfortunate, as the rapid growth of willows and other bulb vegetation just behind the levee caused considerable annoyance and expense. It would have been much better

PLATE CXXIV.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
CORY ON
IRRIGATION AND RIVER CONTROL,
COLORADO RIVER DELTA.

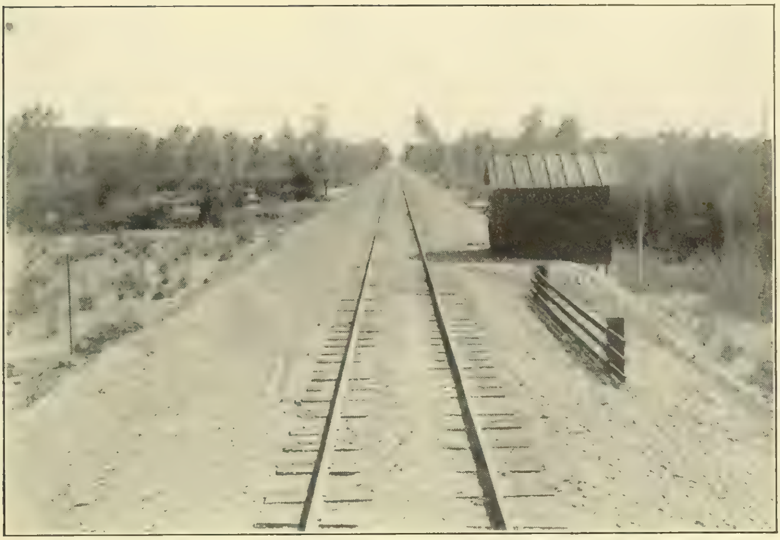


FIG. 1.—TYPICAL SECTION OF COMPLETED LEVEE, WITH INTERRUPTED BORROW-PITS ON THE RIVER SIDE.

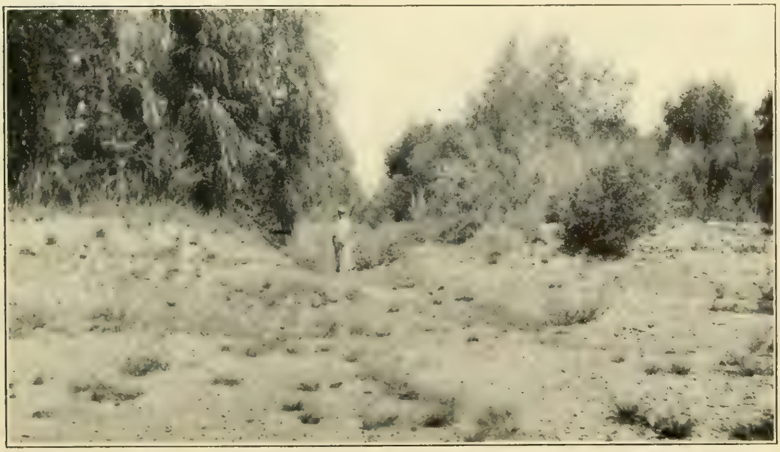


FIG. 2.—CONNECTING CHANNEL ERODED BETWEEN INTERRUPTED BORROW-PITS DURING SUMMER FLOOD, 1907.

to have put the line on the land slope, about 9 ft. from the center of the levee.

At each mile post a 6 by 8-ft. wooden tool and telephone house was put up, and white boards were nailed to telephone poles at points half way between, to mark the ends of the patrol beats. When floods are expected, sacks, tools, etc., can be distributed and kept in these houses, but between times it was found impracticable to leave anything but the telephones on account of malicious and thieving passers-by. It was also found that the heat in these houses during the summer was sufficient to melt down and spoil many of the rubber receivers, so that only metallic ones are now used.

General Data.—The total length when complete was 15 miles of main levee, having an average height of 8 ft. and an average muck-ditch yardage of from one-third to one-fourth of the main section, and 1.6 miles of spur levee, with a height of from 20 to 4 ft. and a muck-ditch yardage of about 15% of the main section. The quantities and costs of the extension work after the second break were as follows:

154 500 cu. yd. muck-ditch excavation at 18½ cents.
49 700 " " " " refilling, which was twice handled, at 10 cents.
443 000 " " embankment at from 18½ to 25¾ cents.
166 700 " " original specification at 18½ cents.
100 800 " " wide check at 19 cents.
154 545 " " checkerboard system at 25¾ cents.
9.66 miles of clearing and grubbing, $2 000.

Enlarging Main Canal and Building Secondary Levee on Canal Bank.—On November 26th, 1906, the *Delta* cut its way into the Main Canal just below the Boundary Line and commenced deepening it and building a secondary levee on its river side beginning at the concrete head-gate and working down stream. It reached the Lower Heading and connected the levee bank with the north end of the Hind Dam in May, 1907, and started back, improving the work at various places and continuing this until July 21st, 1907. This levee was built in exactly the same way as those around the Reclamation Districts of the Sacramento River, and was made with a minimum height of 3 ft. greater than the main levee opposite along the river bank. While not a very efficient construction, it, nevertheless, will serve to prevent water from getting into the Main Canal from breaks in the main levee until they can be repaired.

Criticism of Levee Work Done.—All parties interested assumed that the Harriman interests were doing work in the capacity of a contractor for the United States Government, and not in any sense in its own behalf, and that the engineers of the Reclamation Service were "available for consultation." Certain of these engineers, individually, criticized the excavation of the borrow-pits on the land side of the levee, and so a request was addressed to the U. S. Reclamation Service for a Consulting Board to consider the situation and make recommendations. Such a Board was appointed, all being members of the Service, consisting of A. P. Davis, W. H. Sanders, D. C. Henny, and Francis L. Sellew, Members, Am. Soc. C. E. This Board inspected the works then under way, and on January 10th reported, recommending among other things that:

"4. Borrow-pits should be on the water side, berms between them of greater width than the pits, and care should be taken not to disturb the vegetation on the berms, which should also be protected at frequent intervals with barbed-wire fences of 4 to 5 wires, the bottom of which is at the surface of the ground * * *.

"7. The levees now built should be provided with cut-off trenches under the water slope and later provided with sheet-piling reaching below borrow-pits * * *.

"8. All levees should be blanketed with gravel on water slope and railroad track maintained on the levee."

The clearing for half of the extension work was done at this time, and the work already started was continued as theretofore. Fear of erosion trouble, because of borrow-pits on the river side, and correspondence with the New York office of the Harriman Lines, resulted in the appointment of another Consulting Board consisting of Messrs. L. C. Hill, M. Am. Soc. C. E., W. H. Sanders, and F. L. Sellew, of the U. S. Reclamation Service, and William Hood, M. Am. Soc. C. E., Chief Engineer of the Southern Pacific Company, which met at Yuma, thoroughly examined the work, and reported on February 14th, among other things, as follows:

"*Existing Levee Between Cement Head-Gate and Dam Across Lower Intake.*

"Spur dikes (traverses between borrow-pits) to be increased in width to at least 50 ft. on top and to be at least 4 ft. in height above the general level of the original surface of the ground, and to extend at least 300 ft. northerly from the northerly edge of the borrow-pits, and in this 300 ft. no borrow to be made on either side of this levee and no brush to be cut outside of the limits of the slope stakes.

"The end of the levee and for some distance on the sides on each side near the end to be thoroughly brushed.

"These cross-dikes to be not to exceed 600 ft. apart, and where now located essentially farther than this, an intermediate cross-dike to be put in * * *.

"An abatis work, being in effect a wire and brush wing dam, shall be built from a point on the slope of the levee nearest the river, situated well above high water, and such wing dam pointing down stream, approximately, per local conditions, at an angle of 45 degrees to the levee.

"This to be made with suitable posts or stakes driven into the levee and between the levee and existing trees and thence by assistance of trees acting as posts or stakes and suitable barbed wire fencing in two lines not less than 2 ft. apart, and the whole filled with brush thoroughly wired down.

"These wing dams to occur at no greater distance apart than 500 ft. * * *.

"Levee Below Dam Across the Lower Intake, This Being Partly Completed and Under Construction.

"The same remarks as to spur dikes and abatis work apply as stated above with reference to existing levee between the cement head-gate and the dam across the lower intake * * *.

"For the levees as constructed, material has been taken from the land side instead of the river side, as recommended by the previous Consulting Board of the Reclamation Service.

"As these conditions now exist, the present recommendations are with a view to make the levees as secure as practicable under present conditions * * * . As to the still unconstructed portion of the 10¼ miles of levee now intended to be constructed southwesterly from the dam across the lower or Mexican intake, this unconstructed portion being several miles, we recommend and expect that the recommendations of the Consulting Board of the Reclamation Service as to the position of the borrow-pits; position, depth and character of muck-ditches, and all other matters, be strictly complied with."

Accordingly, the additional levees constituting 4.11 miles at the south end were built with muck-ditch under the river slope and with borrow-pits on the water side of the levee. These pits are 100 ft. lengthwise of the levee, with spaces between them 100 ft. in width, on which every care was taken not to disturb the vegetation to the water toe of the levee. This method of borrow-pits is known locally as the "checkerboard" system.

It is obvious that the checkerboard system requires an average haul of excavated material of about 175 ft. in excess of that required by the ordinary plan.

According to comparative tests this increase in length of haul and inconvenience in handling teams resulted in increasing the cost of work about 6¾ cents per cu. yd. for embankment only, or approximately 30% of the cost of team work.

It was deemed advisable to complete the main levee high enough to be beyond danger of overtopping by floods before doing anything on the spur levees between the land side borrow-pits recommended by the Consulting Board on February 14th. About the middle of May bids were asked for constructing them (described in the first item of the report of the second Consulting Board), and the lowest bid was $40 per acre for clearing, $80 per acre for grubbing, and 31 cents per cu. yd. for embankment, making their estimated cost between $12 000 and $12 500 per mile of main levee. Accordingly, a third Consulting Board was requested, and was appointed by Mr. A. P. Davis, Chief Engineer of the Reclamation Service, consisting of C. E. Grunsky, Consulting Engineer to the Secretary of the Interior; L. C. Hill, and F. L. Sellew, which Board met on June 19th and recommended as follows:

"1. That in lieu of the general system of cross-dikes recommended by the second Consulting Board:

"(a) To complete at once the cross-dikes now being constructed about 500 ft. southerly from the south end of the Clarke dam, making it 10 ft. wide on the top and giving it the same height as the crest of the spur levee with which it connects;

"(b) To construct a second cross-dike about 500 or 600 ft. southerly from the first, also 10 ft. wide on top and with a height the same as the crest of the spur levee with which it connects;

"(c) To construct cross-levees, with crest at least 4 ft. above made ground (tops 10 ft. wide) between the main levee and the secondary levee [along the east bank of the main canal from the concrete head-gate to the north end of the Hind Dam. H. T. C.], near or on the southerly bank of the old upper Mexican intake, and a second within about 1 000 ft. of the southern end of the secondary levee."

This recommendation was carried out.

Summer Flood of 1907.

The levees, including the secondary one along the Main Canal and the cross-levees mentioned in the recommendations of the last Consulting Board of the Reclamation Service, were completed on July 21st, 1907, and the Epes Randolph, Agent, fund was closed. The *Delta* continued deepening the Main Canal and at the same time raising and strengthening the secondary levee on its river side for 3 months longer, but it was estimated that the cost of such work balanced the deepening of the Main Canal done while strengthening the same secondary levee, prior to that date. After that time all charges for maintenance and operation of the head-gates and levee system were made by the Mexican Co. against the C. D. Co.

The flood of 1907 was a record one in total discharge, and probably would have been in gauge height reached at Yuma had it not been for the unusual conditions lower on the river. The old channel of the Colorado was considerably higher than usual, from the point of diversion to the Gulf, the erosion since the diversion and until the coming of the summer flood being of not much importance. It had been silted by the very small quantity of water carried as the re-diversion became more and more a reality, and, in addition, it was appreciably raised by the flood of December 5th which stranded quantities of heavy silt.

The vegetation of the lower delta lands depends on the annual overbank flows, and these lands had not been covered for two seasons, due to the river diversion north of the delta's dividing ridge, much of the light vegetation had perished, and large tracts of the region had been burned over. In designing the levee system it was deemed conservative practice not to take into account any such increased overbank flow, and to consider that the whole channel would be much less efficient and would deepen much more slowly than usual under the coming summer flood, on account of the fact that the bed had been undisturbed for 2 years, and hence was compacted and dry. However, the flood of 1907 came up very gradually, and eroded the bed most satisfactorily, and an extraordinary quantity of water went overbank, particularly to the west because of the greatly decreased vegetation. It thus happened that this record flood, confined between levee banks only 1 500 ft. apart, rose to only an average of about 6½ ft. below the top of the levee, varying from a minimum of 6 ft. to a maximum of 7 ft. The water got against the levees for their whole length, however, testing the muck-ditch construction thoroughly, and in no case was any weakness apparent.

The water-table throughout the region was raised above the bottom of the borrow-pits in many places, so that a considerable quantity of water, in some cases 2½ ft. in depth, slowly seeped into these pits. This water was always perfectly clear, came in very slowly, and gauge readings, kept in many of them and in pits nearby, showed that the levels in them fluctuated with the adjoining water-table at all times. As the flood went down, these waters lowered and disappeared, and a rapid growth of willows started, so that a very large part of the borrow-pits is now overgrown with a dense growth, many bushes attaining a height of 20 ft. in 2 years.

Much difficulty has been found in keeping Indians from clearing away such growths and utilizing the borrow-pits as garden patches. Indeed, the Mexican officials practically take the position that, while the land is private property belonging either to the Mexican Co. or the C. M. Co., the nomadic Indian tribes have for many years been free to live their Gipsy life therein; that the levee system has cut off the annual inundation on which these people depended for their garden crops; and that it is unreasonable to insist on preventing them from taking these borrow-pits for gardening purposes, particularly as they are prevented from making clearings and utilizing inundated land in front of the levee.

A very striking occurrence was the complete filling up of the diversion channel between the river and the Hind-Clarke Dam. In many places this was more than 45 ft. in depth and probably averaged 20 ft. for 2 800 ft. up and down the river and 3 300 ft. at right angles thereto, an area of 210 acres. When this summer flood had passed, there was only a little pool about 5 ft. deep immediately above the Hind-Clarke Dam where the water had been deepest. Two years later this area was so densely overgrown with willows that it was extremely difficult to believe that the break ever occurred there. Until this silting up in front of the Hind-Clarke Dam began, numerous small boils appeared in the sand bar formation behind the Hind Dam. These at no time were of any importance, and soon ceased. Behind the Clarke Dam, practically no seepage whatever occurred.

The very slight percolation of water under these structures was rather surprising and very gratifying, considering their non-homogen-

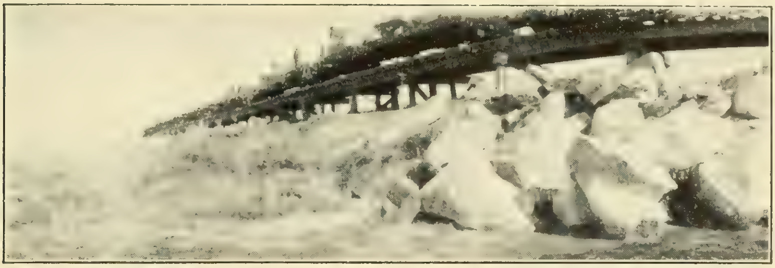


FIG. 1.—SECOND CLOSING. HEAD DEVELOPED, 8 FEET.

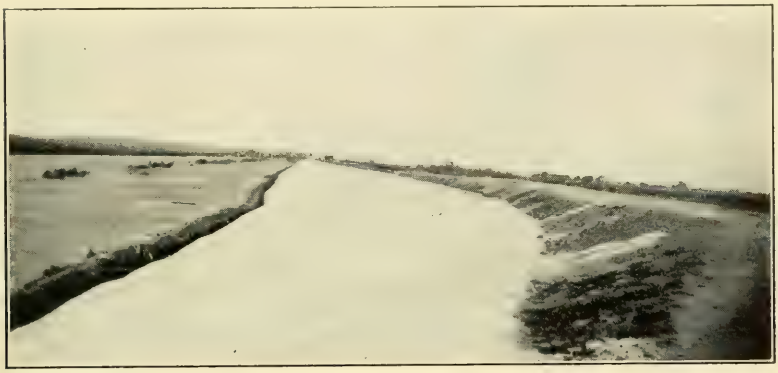


FIG. 2.—REINFORCED CONCRETE FACING, ON LEVEE 25 FEET HIGH, NEAR SACRAMENTO, CAL.

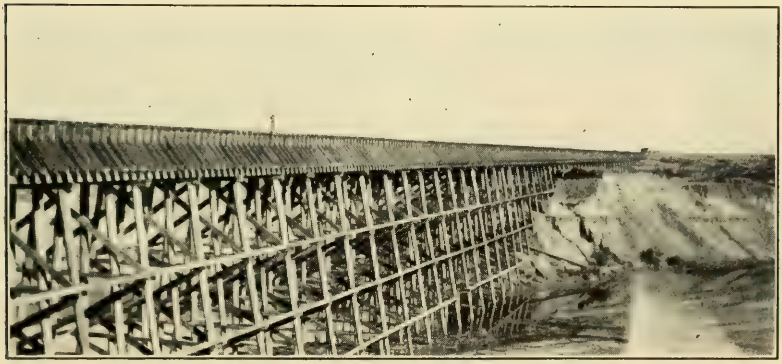


FIG. 3.—WOODEN FLUME OVER NEW RIVER BARRANCA.

eous structure and the character of their foundation. Nevertheless, it accords with the experience with the wooden and concrete head-gate coffer-dams, and the pumping of water into the Main Canal to keep the *Alpha* afloat, namely, that seepage through the alluvial soil of the region is remarkably small.

The water-table, for considerable distances on each side of the river, rises and falls with the water surface, especially during the summer floods, with small lag in time. The writer has always considered these two facts incongruous, and has never been able to find a satisfactory explanation.

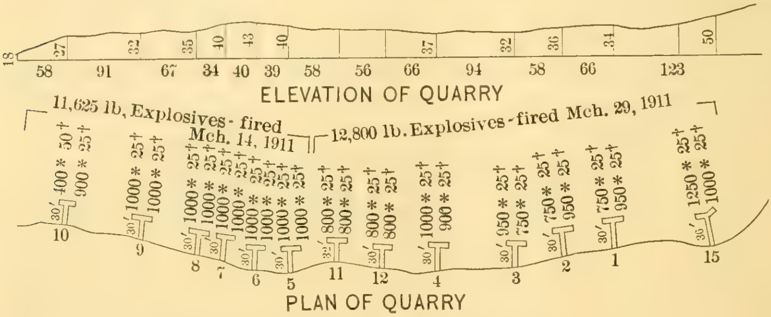
Maintenance of Levees.

Until the summer flood of 1907 had passed, the levees were very carefully patrolled, watchmen being stationed night and day at each telephone house. A considerable store of timber, large and small, has always been kept at the Lower Heading until recently, and a storehouse containing a large quantity of shovels, picks, crow-bars, track tools, and lanterns has been maintained at the upper end of the Hind Dam. In this, from 20 000 to 50 000 sacks are always kept, being drawn on for use in the valley and replenished to avoid depletion. Until a number of flashy floods had passed, a work train was always ordered from the Southern Pacific on reports from the head-waters indicating large rises in the lower river, and sacks were taken from the storehouse and distributed up and down the river, 500 at each toolhouse. Confidence in the effectiveness of the dikes soon grew, so that this is no longer being done.

In spite of the gravel blanketing, vegetation started up slowly, and is kept down by constant but relatively inexpensive work. Considerable annoyance is caused by insects, particularly large burrowing ants which make great ant-hills and holes. These are destroyed by pouring gasoline into the holes and burning it.

As the value of rock, in repairing breaks or in river protection work, to prevent the side cutting of banks from breaching the levees, made it advisable to have a large quantity ready in the Andrade quarry, about 50 000 cu. yd. were blown out ready for handling by steam shovels. This was done by "coyoting" or driving 3-ft. tunnels horizontally about 30 ft. into the foot of the rock face, at intervals of 60 ft., and driving cross-tunnels at the ends, 10 ft. on each side.

These cross-tunnels were loaded with black powder, which was all exploded at one time. All this rock has been taken away, and has left the quarry with a practically vertical face, averaging 50 ft. in height for a length of 1 000 ft., a very satisfactory condition. An American Hoist Company's 10-ton steel derrick with a 60-ft. boom, erected to handle this rock, proved very efficient and satisfactory. The railroad north of Andrade was raised above flood heights, the quarry lines were thrown over, and a track was laid on the top of the concrete head-gate, stringers being laid on the cellular pier walls. This track was connected with that on the levee, so that a train could be loaded at the quarry and run over the concrete head-gate and down the levee system, using the main line of the Inter-California Railroad only

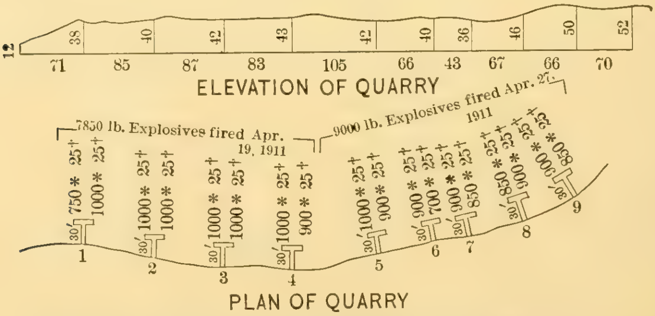

ELEVATION OF QUARRY
11,625 lb. Explosives - fired Mch. 14, 1911
12,800 lb. Explosives - fired Mch. 29, 1911
PLAN OF QUARRY

CHAMBER BLASTS AT ANDRADE—FIRST SET

Pounds, Judson Powder_____* Pounds, 40% Giant____†

Loosened up 51,600 cu. yd. Swell, 10,000 cu. yd. Material broken small

FIG. 25.


ELEVATION OF QUARRY
7850 lb. Explosives fired Apr. 19, 1911
9000 lb. Explosives fired Apr. 27, 1911
PLAN OF QUARRY

CHAMBER BLASTS AT ANDRADE—SECOND SET

Pounds, Judson Powder_____* Pounds, 40% Giant _____†

Loosened up 58,000 cu. yd. Swell, 1,300 cu. yd. Material broken small

FIG. 26.

for that portion lying on the Hind-Clarke Dam. In the fall of 1907 this railroad was reconstructed and repaired from Calexico to Cocopah, and extended through to the end of the spur levee. The track from this point to Hanlon's Junction was taken over by the Southern Pacific Company, in accordance with arrangements made when the branch line was built. For this, consisting of 61 miles of main line and 21 miles of siding, the Inter-California paid the C. D. Co. approximately $65 000. When this was done the branch line was no longer available for use by the irrigation company, but the right to use the east track or siding on the Hind-Clarke Dam was retained, and the Inter-California was specifically released from any obligation to maintain the dam.

It certainly is not often that a diversion head-gate carries a main-line, standard-gauge railroad, and the fact that this does will give some idea of its size. By thus utilizing it, the heaviest carloads of rock from the Andrade quarry can be hauled over the levee system, and be independent of the Inter-California tracks.

THE SOUTHERN PACIFIC NOT REIMBURSED BY THE UNITED STATES GOVERNMENT.

Early in 1907, a bill* was introduced before Congress:

"To reimburse the Southern Pacific Company the amounts expended by it from December first, nineteen hundred and six, to November thirtieth, nineteen hundred and seven, in closing and controlling the break in the Colorado River.

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of one million six hundred and sixty-three thousand one hundred and thirty-six dollars and forty cents is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to reimburse and pay the Southern Pacific Company the amounts paid by it from December first, nineteen hundred and six, to November thirtieth, nineteen hundred and seven, in closing and controlling the break in the Colorado River and thereby saving the overflow and destruction of the Imperial Valley in southern California."

This bill was referred to the Committee on Claims, of which Hon. James M. Miller, of Kansas, was Chairman, and consideration was begun on February 24th, 1908. At this hearing Mr. Maxwell Evarts,

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* H. R. 13 997, Sixtieth Congress, First Session.

Counsel of the Harriman Lines, Mr. P. G. Williams, of the Accounting Department, who had been in charge of the accounts of the Epes Randolph, Agent, fund, and the writer, appeared to make explanations and present for examination vouchers covering all items of expense. President Roosevelt was frank and open in urging the justice of the claim, but, of course, was not advised as to whether such amount of money had been expended. Everyone else, however, seemed to be very much afraid of the matter. The Committee on Claims desired information as to the character of the work done and the fairness of the charges therefor, and asked the Secretary of the Interior, James R. Garfield, to have the Reclamation Service Engineers investigate and make a report. The reply was that no funds were available for that particular kind of work. Accordingly, President Roosevelt asked Secretary Garfield, F. H. Newell, M. Am. Soc. C. E., Director of the Reclamation Service, and Mr. Walcott, formerly head of that Service, to take up the matter and report on what the Government, as a matter of moral and equitable obligation, should pay for the service rendered. President Roosevelt at the time, March 11th, in a letter to the Chairman of the Committee on Claims, advised him that this had been done; recalled the dire need for immediate action at the time; stated that negotiations with Mexico were then under way for future action in concert between the two nations; that he did not think the Southern Pacific people should be obliged to wait for the conclusion of these negotiations between Mexico and the United States with regard to future action, but that a rough estimate should be made as to what the United States should pay as reimbursement to the Southern Pacific Railroad, and that it was an act of justice to deal generously in the matter, for the railroad, by its prompt and effective work, rendered to a threatened community a notable service which could in no other way have been done. To facilitate matters, Mr. Evarts agreed with the Committee that Mr. Grunsky, who had been Consulting Engineer of the Secretary of the Interior on all Reclamation Service matters until a few months previous, and who, of all Government engineers, knew most about the Lower Colorado River and the operations of the Southern Pacific Company, should be engaged by the Committee to report on the work done and the expenditures, and that Mr. Evarts would advance the expenses of such investigation and report.

Mr. Grunsky, with the assistance of the American Audit Company, of New York City, investigated the accounts, and reported on April 1st that the structures along the river were adequate and efficient, and fulfilled their intended purposes; that additional protective work would have to be done in the near future; that charges incurred prior to December 7th, 1906, and subsequent to July 21st, 1907, were not properly chargeable to work done as a result of correspondence between the President and Mr. Harriman; that the quantities of material, such as rock, gravel, and earth, covered by the expenditures could not then be ascertained by measurement of completed structures with any degree of precision; that the records presented by the company showing the quantity of rock, gravel, and clay put into the work from day to day from January 27th to July 18th, 1907, during which time practically all the work of closing the second break and completing the protection work was done, constituted a reasonable check on the bills rendered, and that the number of carloads of material handled prior to January 27th, 1907, was no doubt correctly reported; that a fair basis for all charges, everything considered, would be cost plus the usual 10% for superintendence, tools, etc.; that this basis had been followed in the accounts, with the exception of the freight, which had been billed at tariff rates and really should have been made at 0.5 cent per ton per mile; that the accounts revised and corrected according to the foregoing showed the total net expenditures to be $1 083 673.97, exclusive of interest.

TABLE 18.—EXPENDITURES ON THE COLORADO RIVER WORK SUBSEQUENT TO DECEMBER 1ST, 1906.

Labor	$275 310.12
Materials and supplies	261 969.04
Fuel	33 339.58
Freight charges on supplies and materials	613 150.84
Freight fuel	19 073.00
Transportation	12 395.23
Work-train service	7 627.17
Rental of equipment	70 507.54
Commissary supplies and labor	8 356 27
Trackage	31 981.00
Construction of additional levees (contract)	255 378.55
Officers' and clerks' salaries	8 449.08
Office expenses	1 279.20
Traveling expenses	1 437.65
Sundry expenses	1 091.39
Duties	34 717.45
Total	$1 636 063.11

Mr. Grunsky's report was clean-cut and fair, the inclusion of freight charges at tariff rates being done against the writer's advice.

The Committee on Claims, therefore, now had definite ideas as to the work and cost. The report to President Roosevelt from Messrs. Garfield, Newell, and Walcott (dated March 17th), and mentioned in his letter of March 11th, as to the fair proportion to be repaid the railroad, was forwarded to the Committee, and, after reviewing the situation, including the exchange of telegrams between Mr. Harriman and President Roosevelt on December 19th and 20th, 1906, states:

> "Under the circumstances, we do not feel justified in attempting even in a rough way to approximate the burden, other than to state that the principal beneficiaries are six in number: (1) The settlers in the Imperial Valley; (2) the Southern Pacific Co.; (3) the California Development Co.; (4) the Mexican Corporation; (5) the Republic of Mexico, and (6) the United States. Not considering the settlers in the valley, we have five distinct entities among whom the burden might be distributed more or less equally. Thus, a rough estimate might apportion to the United States 20 per cent. of the money expended to reimburse the Southern Pacific Company for the actual expenditures of repairing the break in Mexico. Such proportion would fully comply with your suggestion that the United States Government should act generously toward the Southern Pacific Company, for by prompt and effective work it rendered a notable service to the threatened community of settlers in the Imperial Valley, quite regardless of the ultimate benefit of such action to the railroad company itself."

This recommendation has always seemed remarkable to the writer. The land interests in the Imperial Valley on both sides of the Boundary Line represent fully two-thirds of the present property values which had been threatened; the Southern Pacific Company about one-sixth; the United States, through its Laguna Weir, about one-sixth; the C. D. Co. and the Mexican Co. nothing, because they were both bankrupt, and the Republic of Mexico practically nothing because its interests conserved were wholly prospective, as well as those of the United States as far as irrigable land farther up the river is concerned. Furthermore, it was known that $950 000 had already been subscribed by the people and corporations in Imperial Valley when the President called on Mr. Harriman to start work, as he did and at once stopped such subscription. It is obvious that the railroad could by that time in no possible way collect anything from any other source than the United States for such work, so that such payment as might be made by the United States will represent the grand total reimbursement. Just why this Committee eliminated the land owners and then considered the remaining five entities as being equally concerned has always seemed remarkable, especially because, when two years later another call for help from Imperial Valley came to President Taft, Congress at once appropriated $1 000 000 to protect the land owners primarily and almost exclusively.

The Committee took no action in the matter until Congress adjourned, and two years later, at the next session, another bill was presented, this time in the Senate (Senate 417, Sixty-first Congress). The matter was gone over again, and the bill with the amount cut to $773 647.25, or 71.4% of that reported by Mr. Grunsky, passed the Senate. The House Committee on Claims made a favorable report. Five members of the Committee submitted a minority report on January 28th, 1911, stating that they did not think there was any legal, equitable, or moral obligation on the part of the Government to pay the railroad company any amount whatever for closing the break; that expenditures were made neither at the request of the Government nor for its benefit; and that the appropriation of such sum would be "Purely a gratuity, a gift of the people's money to the Southern Pacific Railroad Company * * *.

"We oppose this proposed gift to the Southern Pacific Railroad Co. as well as all other gratuities to private enterprise."

The bill did not pass the House.

Damages Caused by the Runaway River.

The first damage caused by the diversion of the river was the flooding of the salt beds and the gradual burying of the entire plant of the New Liverpool Salt Company in the bed of the Salton Sea. The property was probably worth about $125 000.

As the waters continued to rise, they began to threaten the main line of the Southern Pacific Company throughout the basin, and in July, 1905, they reached the rails for a considerable distance. Shooflying was begun and continued from time to time, nothing very aggressive being attempted because of optimistic advices as to when the river would be under control.

Shooflies Nos. 1 to 7, inclusive, were at an elevation of —250 ft. or more. Shoofly No. 11 is 39 miles long, and follows the —200-ft. contour, being determined on when the probabilities of controlling the river before the summer flood of 1906 seemed to be rapidly decreasing.

It was built in February and March, 1906, and was located with a view to being safe from the rising waters for at least two years, the estimates being based on the discharge records of the river at the time of building. As a matter of fact, some sections of the track a few feet below the —200-ft. contour were in trouble in the latter part of October, the water then being 47.5 ft. higher than when the line was surveyed. When the second break occurred, Shoofly No. 12, 48.9 miles long and following the —100-ft. contour, was hurriedly surveyed and graded during January and February, 1907, the outside drainage work being completed on April 1st. Track material for this had been gathered at each end—Mecca and Imperial Junction—during September and October, 1906, when Shoofly No. 11 was threatened. Practically none of the bridging was put in on this latter work, and when only about 4 miles of track were laid it seemed that the river control work would prove effectual, and work was consequently ordered stopped.

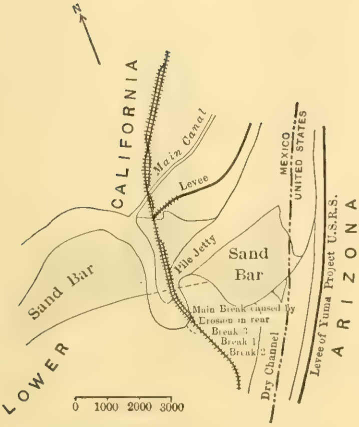
The railroad company also suffered damage along the branch line between Imperial Junction and Calexico. At the crossing of the Alamo River north of Brawley the track was moved five times, the present alignment constituting a shoofly 2 706 ft. long, and introducing 105° of curvature, as compared with 16° 40′ originally. A few miles south, the enlargement of the New River channel made it necessary to construct three shooflies, the last one being 9 086 ft. long and containing 121° of curvature, as compared with 11° in the original alignment.

The total expenses incurred along the Salton Sea, exclusive of the cost of grading Shoofly No. 12, were as follows:

Year.	Labor.	Material.	Totals.	
1905	....	....	$148 183.71	
1906	$181 300.37	$307 763.58	489 063.95	
1907	49 875.96	37 678.08	87 554.04	
				$724 801.70

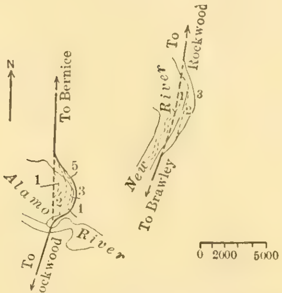
The damages sustained on the Imperial Branch were as follows:

Year.	Labor.	Material.	Totals.	
1905	....	....	$5 914.01	
1906	$19 222.37	$9 986.53	29 208.90	
1907	2 597.13	142.76	2 739.89	
				$37 862.80



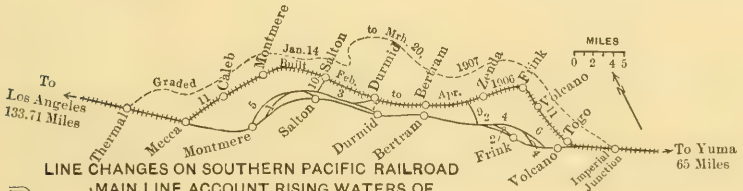
LOCATION OF THE
SECOND BREAK DEC. 7, 1906 AND OF
SECOND CLOSING JAN. AND FEB. 1907

FIG. 27



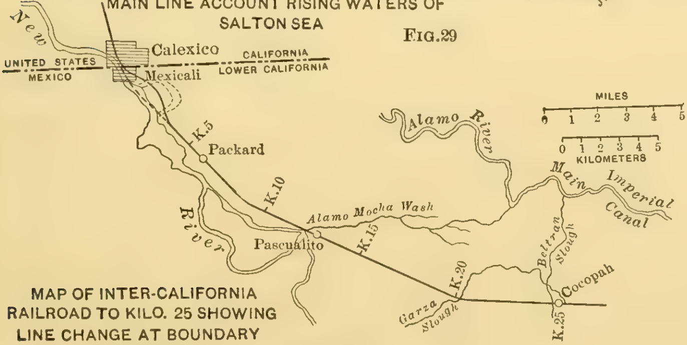
FIVE SHOOFLYS ON THE IMPERIAL BRANCH S.P. CO. AT CROSSING OF ALAMO RIVER AND THREE SHOOFLYS BESIDE THE NEW RIVER BETWEEN ROCKWOOD AND BRAWLEY

FIG. 28



LINE CHANGES ON SOUTHERN PACIFIC RAILROAD MAIN LINE ACCOUNT RISING WATERS OF SALTON SEA

FIG. 29



MAP OF INTER-CALIFORNIA RAILROAD TO KILO. 25 SHOWING LINE CHANGE AT BOUNDARY LINE CROSSING

FIG. 30

The Inter-California Railroad, beginning at the International Boundary Line, was damaged more or less seriously for about 10 miles, the details being as follows:

Entirely rebuilding the road through Calexico and Mexicali and beyond, being cost less value of material recovered	$ 82 822.49	
Repairs to remainder of first 10 km., including water supply	4 259.76	
Repairs from 10-km. point to 14-km. point	21 163.73	
		$108 245.98

Thus the damage sustained by the Southern Pacific on permanent way alone, and not including interruptions to traffic, or expenses of any kind incurred by delayed trains, etc., was $762 664.50, and by the Inter-California $108 245.98, making a total of $870 910.48.

In addition to such damages, the trains of rock hauled during the 3 weeks of the first closing and more than 2 weeks of the second closing, or more than 5 weeks in all, were given rights of way over all except passenger trains, and the slower of these were very frequently delayed in order to hurry material to the front. The demand on the equipment of the road was tremendous, particularly during the second closing, when there were in rock-train service, 1 000 flatcars, 300 "battleships," 4 steam shovels, 10 work trains, exclusive of rock trains from the quarries other than at Andrade, etc. Indeed, for about 10 days, practically no freight was hauled out of the Port of San Pedro because of lack of equipment. The degree of the strain is shown by a telegram the writer received from the Superintendent of the Los Angeles Division, just before the second closing was accomplished, asking information as far in advance as possible "when work will slow up because I want to make arrangements to resume operating the division."

About 3 000 acres of cultivated land and 10 000 acres of uncultivated and public lands were practically destroyed and rendered unavailable for agricultural purposes under existing conditions, the total value of which depends on whether the present or prospective worth is considered. Perhaps a very fair figure would be $50 per acre for cultivated land and $10 per acre for raw lands, making the total damage to the land about $250 000.

Various individual settlers in Mexico and the United States suffered more or less severe injury from inundation of crops, etc., as distinct from land damages, and these probably amounted to not more than $150 000. A number of claims for damages sustained on the American side of the line were combined in a suit totaling $490 000, but this included damaged lands estimated at prospective rather than real and present figures.

The most serious injury done to settlers was the entire stoppage of the water supply in the canals of Districts Nos. 6 and 8 from the summer of 1906 until January, 1907. No claim was ever presented for these damages, and nothing more than crude guesses can be made as to the amount. The result practically forced the depopulation of more than 30 000 acres of land, of which about 12 000 acres were under cultivation. The effect on the development of the valley at the time was not very great, but fear of repetition of a break, as much as anything else, has, until recently, retarded the region to a considerable extent.

Because of the tremendous expenditure involved in re-diverting and holding the river in its course, up to December 5th, 1907, when the Southern Pacific advanced funds for the work directly instead of to the C. D. Co., the original $200 000 loan to the C. D. Co. had grown to $1 100 000, and this was swelled by later bills, interests, etc., to approximately $1 375 000, by January 1st, 1909. In addition to owing this large sum for cash actually advanced, and for which payment could not be disputed successfully, a judgment for $458 246.23, in favor of the New Liverpool Salt Company had been rendered in the United States District Court toward the end of November, 1907, and there were claims from the Southern Pacific Company and others aggregating $1 360 000, two-thirds of which were from the latter company. The runaway river rendered hopelessly bankrupt the C. D. Co. and the Mexican Co.

Benefits.

To almost every cloud there is a silver lining, and this is no exception. It is now known that the diversion would have occurred very soon. The event showed the existence and nature of the danger and the necessity for guarding against it. Much more important was the development and standardizing of methods of closing future crevasses which might occur. Incidentally, the information of this character afforded to the Engineering Profession in general will doubtless prove of much value, though this cannot be considered as a benefit to the region in question.

By far the greatest benefit was the erosion of the great Alamo and New River barrancas and the creation of the main features of a complete and comprehensive drainage system for the entire Imperial Valley. The natural slope of the ground is remarkably uniform, with a grade of about 5 ft. per mile, and the very small, shallow channels of the New and Alamo Rivers were the only rudiments of satisfactory drainage, from an irrigation point of view. The Salton Sink is the natural drainage sump for the region, and its absolute control should have been acquired in the very beginning, either by the irrigating company or by the land holders of the valley. In the litigation which followed the destruction of the salt works, the New Liverpool Salt Company, as owner of the submerged land, obtained a decree perpetually enjoining and restraining the C. D. Co. from diverting water from the Colorado River in excess of the substantial needs of the people dependent on the canal for water supply for domestic, irrigation, and such other lawful purposes as the same may be applied to, and with a further provision as to the control of the water diverted so that it will not overflow on the lands of the complainant. Later proceedings resulted in a most remarkable construction of the last portion of the injunction, so that now the Salt Company practically cannot object to the use of the basin as a natural sump. Judgment has just (October, 1912) been rendered for a total of $78 000.

Providing for the region an efficient drainage system to carry all the waters into the Salton Sink would have required a large amount of money—so large that the date of its establishment would have been delayed very far into the future, much too far for the valley's real interests. This is true because it is plainly not the business of an irrigation company to supply a drainage system, and all other interests of the valley are very much divided because of the mutual water company plan of organization, and because of the usual lack of co-operation among farmers. Furthermore, the need for drainage of irrigated land is usually not recognized in time, and not admitted when it is recognized. Indeed, in spite of the rather alkaline character of the lands in Imperial Valley, as already explained, it was not until November 1st, 1911, that any serious suggestion was made for a community drainage canal—in Imperial Water Company No. 8—the reasons then chiefly urged being:

"The loss of ground and bad appearances caused by the ends of the irrigated lands being covered with weeds or wild grass or perhaps nothing at all as the result of standing water."

A few spots in Imperial Valley are beginning to indicate an undesirable increase in alkalinity, and it is most fortunate that the magnificent main drainage ways of the Alamo and New River channels exist.

TABLE 19.—ANALYSIS OF WATER OF NEW RIVER.

Sample taken at Brawley, June 6th, 1908, and submitted by Mr. F. W. Roeding, Irrigation Investigations, Berkeley, Cal.

		Grains per gallon.	Parts per 1 000 000.
Alkali	Potassium Sulphate very small, and Sodium Sulphate (Glauber's salts), etc.	12.87	221
	Sodium Chloride (common salt)	389.40	6 675
	Sodium Carbonate (sal soda)	0.99	17
	Calcium Chloride	14.91	256
	Magnesium Chloride	37.26	639
	Calcium and Magnesium Carbonates, etc., large Calcium Sulphate (gypsum) chiefly	94.29	1 617
	Silica	1.22	21
	Organic matter chars, and chemically combined water	57.44	985
	Total	608.38	10 431

SALTON SEA.

From a geological and spectacular point of view, the creation of the Salton Sea in so short a time was one of the most striking effects of the river diversion. The water filled the basin to a maximum elevation of —197.4 U. S. G. S. datum, or —204.2 S. P. datum, the maximum depth of water being 76 ft. The total area covered at this time was about 445 sq. miles, with a length of 50 miles and a width of from 10 to 15 miles. With the exception of the Great Salt Lake and Lake Michigan, the sea was the largest body of water lying wholly within the United States.

The water rose at the maximum rate during the latter part of June, 1906, when it gained nearly 7 in. per day, or 15.4 ft. during that month. From the reconnaissance map of the Salton Sink, published by the U. S. Geological Survey in 1905, it would appear that the areas of the various contours of the basin are about as follows:

Elevations.	Square Miles.
—280	0
—250	240
—200	445
—150	650
—100	920
— 50	1150
— 0	1750
+ 30 (old beach line)	1950

TABLE 20.—Analyses of Water from the Salton Sea and the Colorado River at Various Seasons.

As made by Dr. W. H. Ross, of the Agricultural Experiment Station, University of Arizona, Tucson, Ariz.

	Salton water, surface of deepest portion, June 3d, 1907.	Colorado River water, low winter stage, January 10th–March 26th, 1900.	Colorado River water, rising summer stage, from melting snow, March 27th–April 30th, 1900.	Colorado River water, summer flood from melting snow, May 1st–June 29th, 1900.	Colorado River water, low summer stage, June 30th–August 26th, 1900.	Colorado River water, affected by local floods, August 27th–October 1st, 1900.	Colorado River water, summer floods from Arizona, October 2d–November 19th, 1900.	Colorado River water, low winter stage, November 20th–January 24th, 1901.
Total soluble solids at 110° Cent. Parts in 100 000	364.8	92.9	67.4	32.2	36.1	71.4	104.5	87.1

Complete Analysis of Soluble Salts, Stated by Ions.

Parts in 100 000.

Sodium, Na	111.1	19.0	15.3	5.5	7.6	14.6	18.2	16.0
Potassium, K	2.3	1.1	2.1	1.0	1.3	1.8	2.1	1.2
Calcium, Ca	9.9	7.5	4.9	4.2	4.6	7.7	12.5	9.2
Magnesium, Mg	6.4	3.1	2.0	1.2	1.2	2.2	2.8	2.8
Aluminum, Al	0.031	....	....	....	....	....	....	....
Iron, Fe	0.005	....	....	....	....	....	....	....
Chlorine, Cl	169.7	20.5	13.9	4.5	6.9	15.8	17.5	18.1
Sulphuric, SO_4	47.6	26.1	19.4	7.2	7.6	19.7	35.6	23.8
Carbonic, CO_3	6.6	7.4	8.4	7.2	7.7	10.0	12.2	10.7
Silicic, SiO_3	1.2	4.6	2.1	2.1	3.3	2.3	2.2	2.1
Phosphoric, PO_4	0.018	....	....	....	....	....	....	....

Practically all the water which enters Salton Sea comes from the Alamo and New Rivers, which, under normal conditions, are now important chiefly as drainage channels for the Imperial Valley. Frequently, however, very heavy precipitation occurs in violent storms over small portions of the area draining into the basin, but the run-off, though occasionally of considerable quantity, is not relatively important. The total annual inflow is at present probably 200 000 acre-ft., or sufficient to cover the surface of the sea about 0.7 ft. in depth, while the evaporation is probably about 6 ft. and the percolation insignificant.

TABLE 21.—COMPOSITION OF OCEAN WATER.

(This table gives the mean of 77 analyses made by the Challenger Expedition, Challenger Report, Physics and Chemistry, Vol. 1, 1884, p. 203.) Stated by Ions. Parts per 100 000.

Sodium (Na)	1 071
Potassium (K)	39
Calcium (Ca)	42
Magnesium (Mg)	130
Sulphate (SO_4)	270
Chloride (Cl)	1 935
Bromide (Br)	6
Carbonate (CO_3)	7
	3 500

Quite a little speculation has been indulged in regarding the length of time which would have been required to fill the Salton Sea had the Colorado River not been re-diverted. Most of such computations are based on too low an average flow of the river past Yuma, which it now seems is in excess of 12 000 000 acre-ft. per annum. As a matter of fact, however, the inflow from the Imperial Valley region will constantly increase, and the quantity evaporated will decrease directly with the decrease in water surface exposed, so that a balance will be reached probably in such time as the inflow will average between 350 000 and 500 000 acre-ft. per annum from all sources, and the exposed surface will cover between 60 000 and 80 000 acres. At such time the maximum depth of the sea will be between 8 and 10 ft.

The sea has already (January, 1912) fallen about 22 ft., and has exposed approximately 115 sq. miles which were under water. The salt beds were dissolved to such an extent as to render the water of the sea quite salt, unfit entirely for drinking purposes, and it was assumed that the land which it covered would be hopelessly alkaline.

This does not seem to be the case, and a very considerable acreage of such exposed land is being cultivated with entire success.

Much speculation was indulged in regarding the effect of this body of water on the rainfall and climate of the Southwest. A careless consideration of the precipitation on the drainage area of the river, particularly that of the Gila water-shed, before and after January, 1905, might lead to the conclusion that the effect is quite marked. The period from January 1st, 1905, to date has been one of very heavy rainfall throughout the Southwest, its most remarkable part being in the early part of January, 1905, which was before the formation of the Salton Sea. Professor Alfred J. Henry* points out the fallacy of such an opinion, as follows:

> "Admitting, for the sake of argument, that a body of water * * * existed * * * 60 miles long, 8 miles broad, and say 25 feet deep on the average. * * * The cubic contents would therefore be 60 x 8 x 0.0047 = 2.2 cubic miles of water. The normal annual rainfall of Arizona * * * is 11.75 inches. [while in 1905 it was 26.6 inches], or an excess of 14.85 inches, an amount more than equal to the normal annual rainfall. * * * As the area of the Territory is 113,956 square miles, * * * the number of cubic miles of rain that fell in Arizona in excess of the average was * * * 27, * * * twelve times greater than the total volume of the Salton Sea. In other words, the total volume of the latter would barely suffice to produce one-twelfth of the surplus rain that fell in Arizona, to say nothing of the rainfall in adjoining regions. The total amount of water now in Salton Sea, if uniformly distributed in Arizona, would cover the Territory to the depth of about an inch and a quarter, or the equivalent of one good soaking rain."

As a matter of fact, the area of the Salton Sea and Laguna Maquata combined are insignificant when compared with that of the Gulf of California, and are just about as far from Arizona. Professor Henry concludes that the Salton Sea has increased the relative humidity in the immediate vicinity in a slight measure; that it is improbable that any considerable portion of the vapor it gives off passes beyond the immediate confines of the desert; and that there might be a tendency toward lower maximum and higher minimum temperatures in a narrow zone immediately surrounding the sea, particularly on the leeward side.

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* "The Salton Sea and the Rainfall of the Southwest," *Monthly Weather Review*, Washington, December, 1906.

International Negotiations.

When the Mexican Co. obtained its concession from the Mexican Government, Col. Jacobo Blanco, then Chief of the International Boundary Line Commission for the Mexican Government, with headquarters at El Paso, was appointed Inspector of the Mexican Co. and its operations. In 1906, Col. Blanco died, and his successor on the International Boundary Line Commission was Señor Fernando Beltran y Puga, who was also appointed his successor as Inspector of the Mexican Co. The writer considers this appointment an exceedingly fortunate one, as Señor Beltran y Puga is an exceptionally efficient, aggressive, and fair-minded man, and an engineer, with whom it has always been a satisfaction to transact business. Immediately on his appointment he acquainted himself with the conditions along the river and with the affairs of the Mexican Co., and has always acted promptly and with decision.

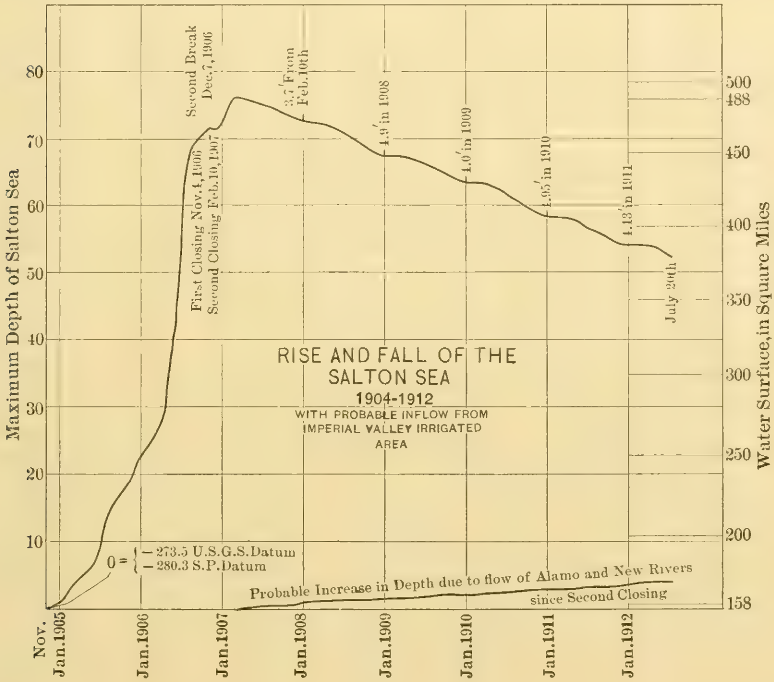


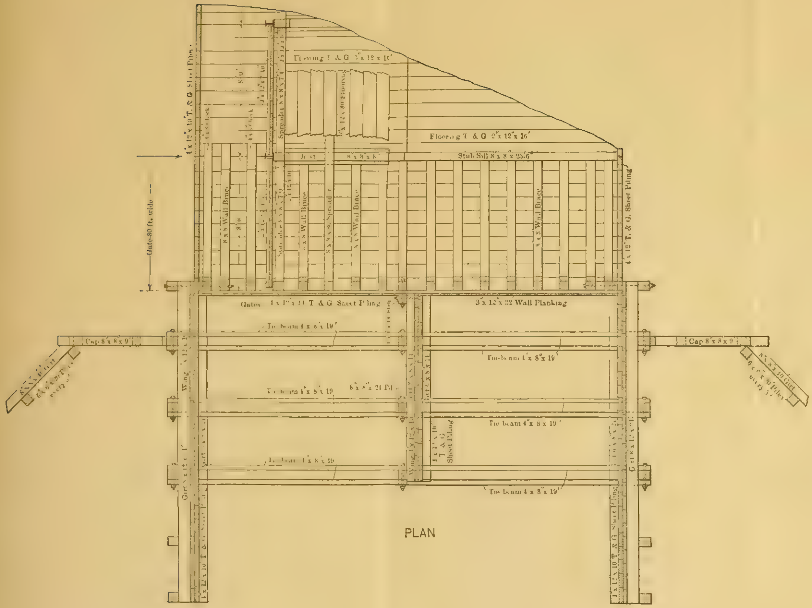
Fig. 31.

In the spring of 1908 the United States State Department appointed Mr. Louis C. Hill, Supervising Engineer of the U. S. Reclamation Service, to represent the United States on a joint commission to work out the provisions of a treaty with Mexico for the control of the Lower Colorado River and an equitable distribution of its waters. This appointment was in line with President Roosevelt's promise to Mr. Harriman, and was doubtless in a measure brought about at this particular time by the failure of Congress to take any action on the bill to reimburse the Harriman interests. At the request of the United States, the State Department of Mexico appointed a Commissioner, and rather naturally selected Señor Beltran y Puga to represent the Mexican Government, this gentleman's appointment being made on May 7th, 1908, and practically simultaneous with the appointment of Mr. Hill. Both gentlemen were instructed to act together and make a study of the works and operations necessary to complete international control of the lower Colorado River and render impossible a repetition of the recent disaster and the complete utilization of the waters of the river, such study to be in whatever detail might be deemed necessary.

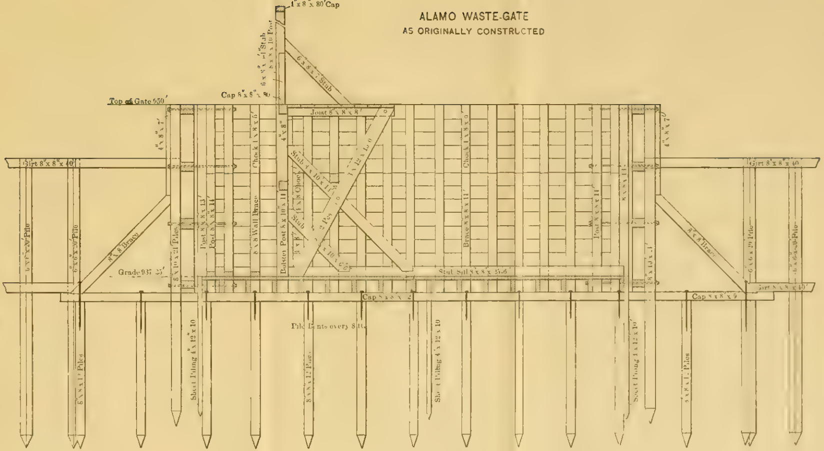
This Commission never had a formal meeting, which is very much to be regretted, considering the importance of the matter. Very shortly after their appointment, the Commissioners had an informal meeting at which, according to private conversations which the writer had with both gentlemen, it appears that Señor Puga submitted, in the form of a written memorandum as the basis for discussion, the suggestion that both Governments cancel the existing treaties regarding the navigability of the river; that regulation of the flow of the river by extensive storage works in the upper portions of the drainage basin was desirable; that both Governments determine the priority and extent of existing water rights and fix rules for granting future water rights; that a joint international commission should make all engineering and other investigations necessary, and divide the costs thereof; that all plans or projects existing or proposed along the river should be submitted to the investigation of the joint commission; that a report be made outlining, in a general way, the work to be done, for the purpose of having a full and complete treaty arranged and the necessary definite appropriations set forth; and that it would be agreeable for Mexico to negotiate a treaty, either preliminary or

ALAMO WASTE-GATE

AS ORIGINALLY CONSTRUCTED



PLAN



ELEVATION

final, at the earliest possible moment. It seems, however, that Mr. Hill could not find time to attend to the matter, nor were special funds placed at his disposal to defray the necessary expenses. At any rate, after two years of inaction, on May 17th, 1910, the United States Department of State recalled Mr. Hill and substituted Mr. Wilbur Keblinger, Secretary of the American Side of the International Boundary Commission with Mexico. Unfortunately, this change of American commissioners did not have any result. Although Mr. Keblinger lives in El Paso, which point is also Señor Puga's headquarters, the Commission has never had a formal meeting.

It is hoped that discussion on this paper will bring out the reason for not dealing with Mexico's commissioner, appointed at the request of the State Department of the United States, particularly as the writer knows Mr. Hill to be an unusually tactful, courteous, and aggressive gentleman, and an efficient engineer. In any event, there seems to be no doubt that the Mexican Government has been not only willing, but anxious, to arrange for a satisfactory joint control of the lower Colorado River, and that the responsibility for nothing of this sort having been done rests with the United States.

Building of Volcano Lake Levee.

The extraordinary quantity of water which got into Volcano Lake during the summer flood of 1907 raised it higher than it had ever before been known to be, and a large quantity of water passed northward through the New River outlet. Furthermore, a reconnaissance showed that the large quantity of overflow water had started cutting back fingers from the Volcano Lake region toward the river, which indicated the probability of the diversion of the Colorado River below the divide of the delta cone, along the Pescadero, Abejas, or Paredones. Therefore it seemed that another portion of the complete levee system, as originally planned by the writer to hold back the overflow waters of the Colorado from the Salton Basin, should be constructed—that portion from the mountains on the west side of the valley eastward along the north of Volcano Lake to the low-lying divide or ridge farther on. The C. M. Co., however, objected to this, as Volcano Lake is entirely on its land and its utilization for irrigating a portion of that company's lands was considered, but found impracticable because of the great variation in the water surface, the inundation of a part of the land, however, at flood times was simple, and permitted securing considerable pasturage. The C. M. Co., however, was willing to give the right of way and permit the construction of the protective works provided a permanent head-gate were installed at Cerro Prieto through which water might be let into the New River when the lake was full. This was finally agreed to, and arrangements were completed under which the Southern Pacific Company agreed to pay the Mexican Co. for constructing this gate on condition that the Mexican Co. would arrange to have 8 miles of levee to the east built. This was done and the gate and levee were completed just before the summer flood of 1908 began to throw its waters into Volcano Lake. After one season the Mexican Government compelled the removal of this intake gate and the levee to be built around in front of it, so that it is not now in service. Plans for the gate and levees were presented to the Mexican Government Inspector of the Mexican Co., Señor Puga, and it was understood that their construction was approved and permission verbally given to begin work before filing maps and drawings and having them approved or changed as required by the Departmento de Fomento in such cases—this on account of emergency. It was not so understood by Señor Puga, and the construction of the gate was a needless expense.

All this work was arranged for and practically done while Congress was considering the payment of the bills for the second closing and subsequent protective work, and when there was no reason to doubt that a fair adjustment would be made.

Reconstruction of Irrigation System.

As soon as the river control work was assured, arrangements were made to ascertain the exact condition of the irrigation system of the valley, and what was necessary and advisable to do in connection with it. Accordingly, Mr. F. C. Herrmann, who was added to the engineering staff on February 1st, 1907, was placed in charge of this work. The damage done by the flood was confined almost entirely to carrying away the flume by which the West Side Main Canal crossed New River, and a similar flume, 20 miles north over New River, carrying water from the Central Main to supply Imperial Water Company No. 8. To rebuild the latter was impracticable on account of the immense barranca which had been created at the old

PLATE CXXVII.
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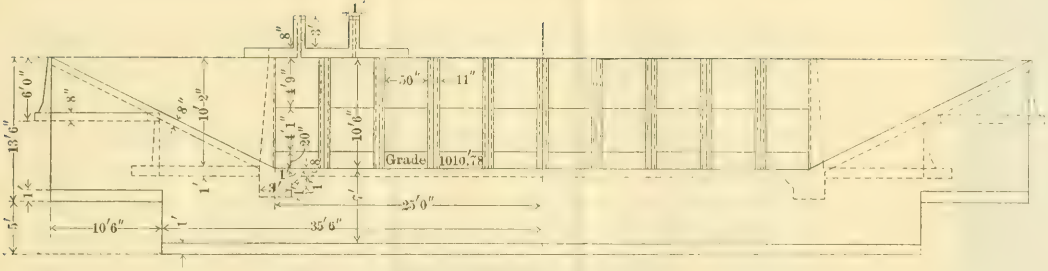
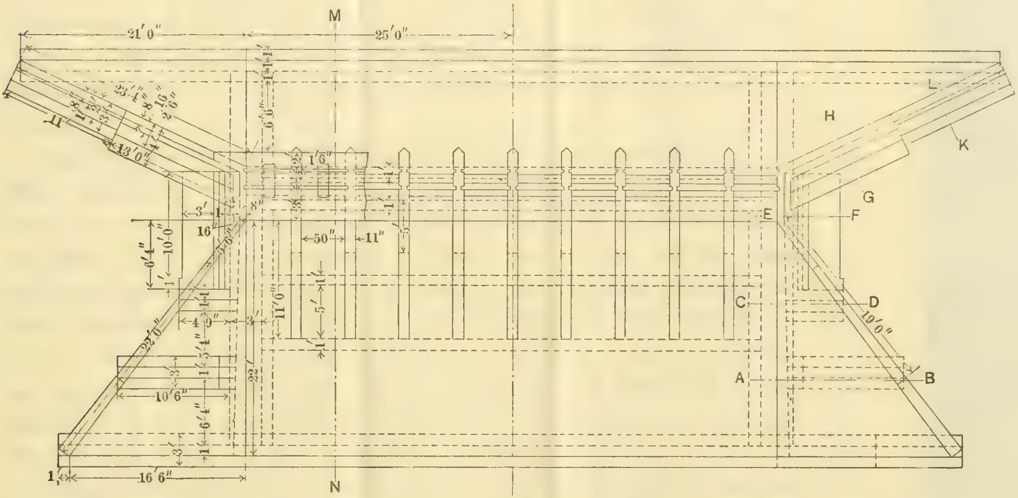
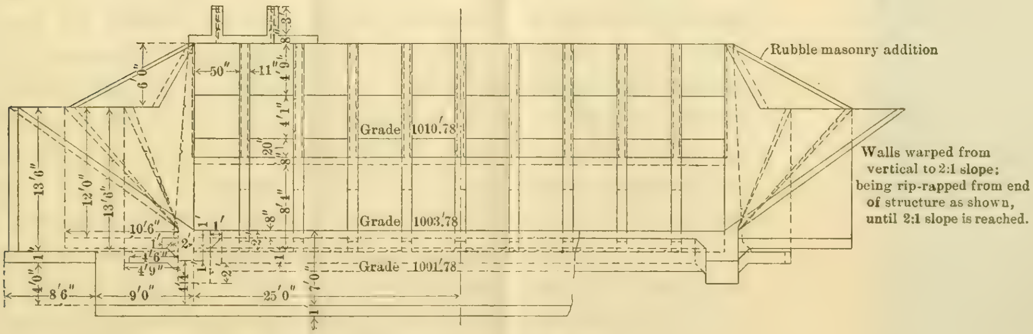


ELEVATION OF UP-STREAM END



PLAN



Rubble masonry addition

Walls warped from vertical to 2:1 slope; being rip-rapped from end of structure as shown, until 2:1 slope is reached.

ELEVATION OF DOWN-STREAM END

crossing, and it was decided to enlarge the West Side Main and extend it northward so that all the territory west of New River would be served thereby.

A wooden flume, supported by wooden piling, was designed to cross the New River gorge very close to the location of the original flume, carried away about March, 1906. Work was begun on the structure and rushed to completion. This flume is worthy of note because of its height, length, and cost, as a quasi-temporary structure. It is 1 860 ft. long and the maximum height of the trestle is 55 ft. It supports a rectangular flume, 16 ft. wide and 6 ft. deep, built of 2-in. redwood lumber with ship-lap joints. It has given excellent service, and the leakage has been notably slight from the time it was first put into service.

Surveys for the reconstruction, enlargement, and extension of the West Side Main were hurried, and contracts were let for the work, which was well under way when the financial panic of November, 1907, occurred. The contractors were forced into bankruptcy, and the work was completed by their bankruptcy trustee, which caused considerable delay, but water was turned through the reconstructed West Side Main late in December, 1907. This canal is 28 miles long—7 miles in Mexico and 21 in California—and has a capacity varying from 800 to 400 sec-ft., with 760 000 cu. yd. of earthwork moved at a total cost of $86 000, and $5 000 for two temporary structures.

Some little time later the Rose Levee, across the Alamo channel at Holtville, was reconstructed, with a waste-gate to pass the excess of water coming through the Holton Power Company's plant and through the Alamo Waste-gate farther up that channel in Mexico, and a head-gate for the Rositas Canal. Both of these are of reinforced concrete, the waste-gate being of interesting design and capable of passing 2 500 sec-ft. with a total drop of 17 ft. In this way water which must be furnished to the Holton Power Company under its contract is picked up below the plant and utilized for irrigation, as was the original intention when the contract was made. These two permanent structures and the earthen dam cost $55 250.

Another important permanent structure, known as the Seven-Foot Drop, was built in the Central Main just south of the Boundary Line at a cost of $23 760, including three small structures adjacent to it. but not exactly a part thereof. This structure takes the place of a wooden 10-ft. drop nearly 2 miles farther on, which, by the way, had passed considerably more water than it was designed for and was in fairly good condition when removed after 8 years of service.

The chute of the Alamo Waste-gate was repaired and again extended down stream, the result being a quite remarkable construction, Plate CXXVI, which has never shown any signs of weakness against a head of approximately 35 ft.

Surveys and Designs for Extensions.—At the same time, surveying parties were assembled and topography taken, with 1-ft. contour intervals, on 230 sq. miles. This included the west side of New River and a strip in Mexico adjoining the Boundary Line averaging 3 miles wide and running from the West Side Main crossing of the Boundary Line to about 4 miles east of Sharp's Heading and thence generally following the Alamo channel almost to the levee system along the river, the Alamo channel being carefully mapped and cross-sectioned. Much of this work was done in the heat of the summer, five complete surveying parties being on the work until after August 1st, when the force gradually lessened. A large part of the area was practically cleared land, but much of it was covered with a dense undergrowth, which made progress very slow, and, by cutting off the breeze, accentuated the severe climatic conditions. Nevertheless, the cost of this work was about 57½ cents per acre, or $37 per sq. mile. This experience showed that, while the great summer heat there is quite disagreeable, it does not render engineering field work by any means impracticable, and indeed does not increase the cost more than 10 per cent. One agreeable feature of the very hot season is that the temperature is too great for flies, so that they practically disappear.

Cross-sections and current-meter observations were taken at various points in the Main Canal and in the important canals of the distribution systems of the various mutual water companies, to determine capacities, losses, etc.

When these data were compiled and put into form, estimates were made for the reconstruction and enlargement of the existing system and for extensions to cover a great deal of new territory. The estimate for this work was approximately $900 000 with temporary structures, and including considerable improvements in the main Alamo channel from the river to the controlling works in the valley; and $2 200 000 with permanent structures at essential points and replacing the Alamo

PLATE CXXVIII.
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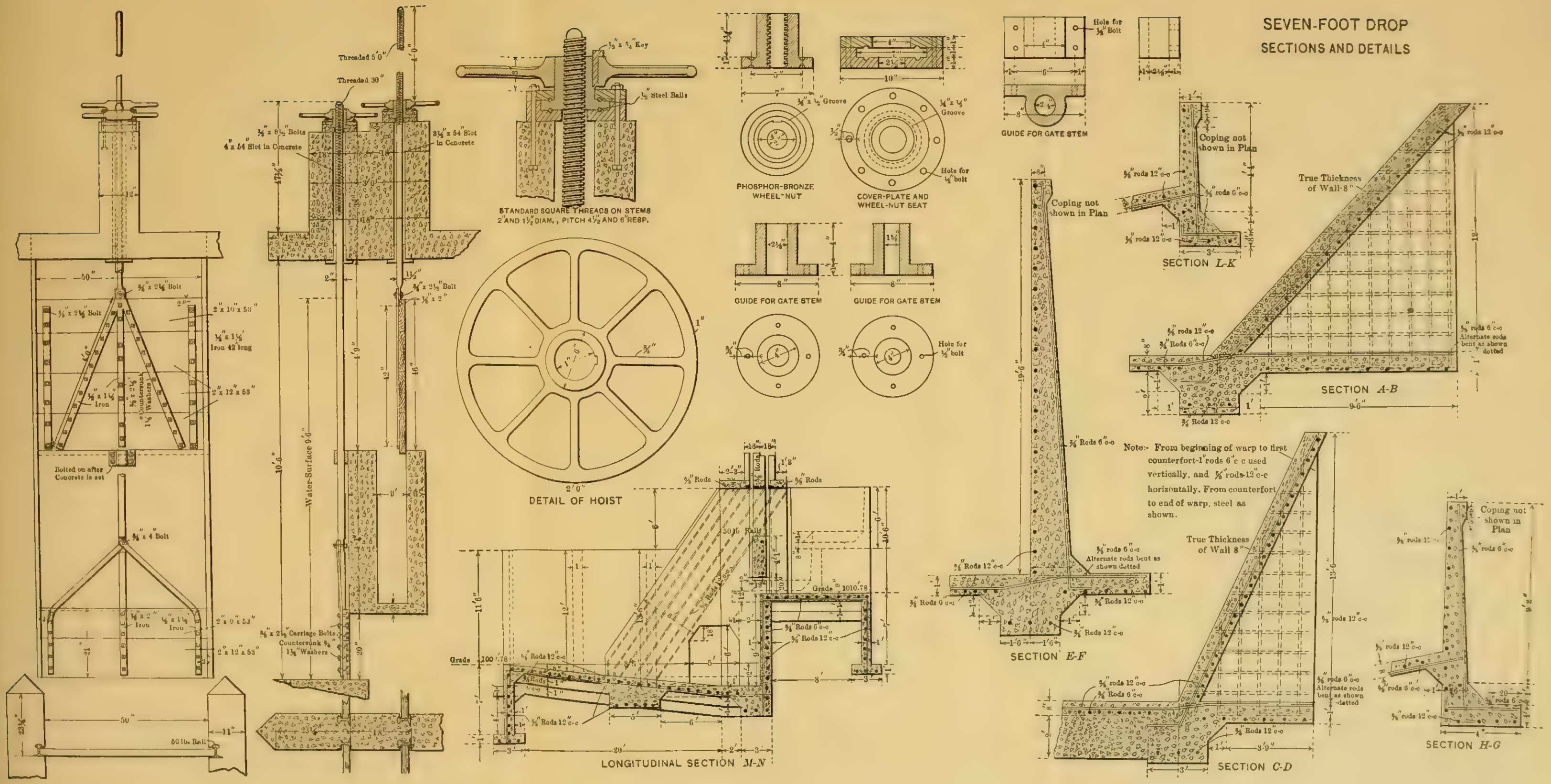
SEVEN-FOOT DROP
SECTIONS AND DETAILS



Note:- From beginning of warp to first counterfort-1" rods 6" c c used vertically, and ⅝" rods 12" c-c horizontally. From counterfort to end of warp, steel as shown.

channel with an entirely new twin main canal from a few miles below the concrete head-gate to the mesa ground east of Sharp's Heading. Whatever possibility there was of such fundamental reconstruction and extensions was dissipated by the severe financial stringency in November, 1907.

These designs included the construction of a head-gate on Mexican territory, and the total abandonment of the concrete head-gate, along with diversion, on American soil. The head-gate thus proposed was just behind the levee, about 3 miles below the Boundary Line, with a caisson foundation supporting extensive wing-walls and massive piers, between which there were to be large vertical gates, operated by gasoline motors.

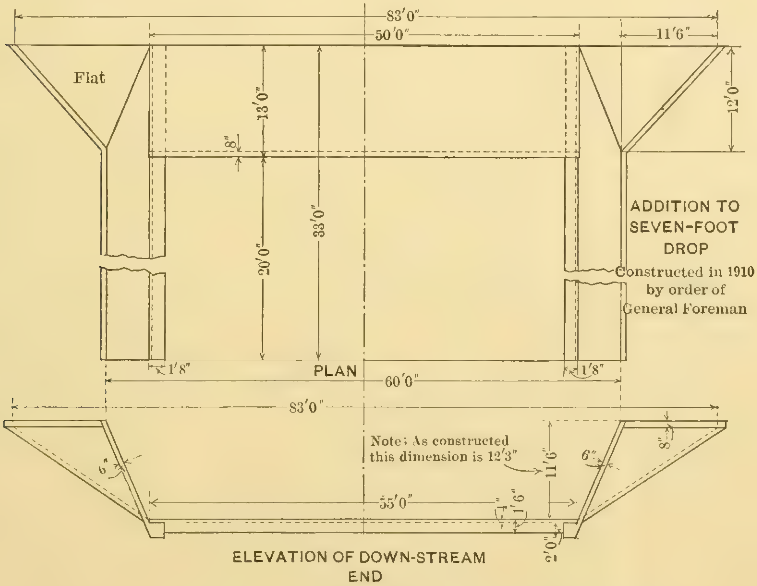
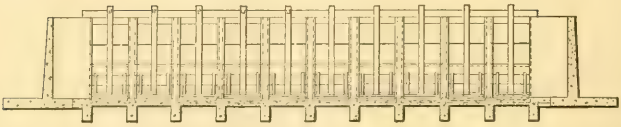

83′0″
50′0″
11′6″
Flat
13′0″
8″
12′0″
33′0″
20′0″
ADDITION TO SEVEN-FOOT DROP
Constructed in 1910 by order of General Foreman
1′8″
PLAN
1′8″
60′0″
83′0″
Note; As constructed this dimension is 12′3″
6″
11′6″
6″
8″
55′0″
1′6″
2′0″
ELEVATION OF DOWN-STREAM END

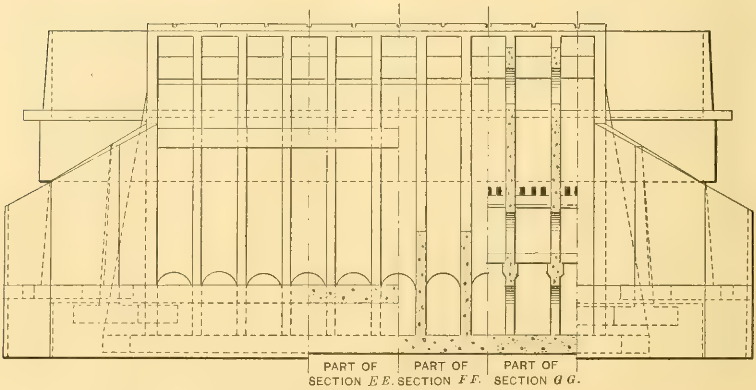
Fig. 32.

Of these designs the only ones constructed were the West Side Main, the Rose Levee and Waste-gate, including the Rositas Heading on the Alamo near Holtville, and the Seven-Foot Drop in the Central Main. The foundations in all cases were merely concrete footings without any sheet-piling, of which the Seven-Foot Drop (Plates CXXVII and CXXVIII, and Fig. 32), and the Rose Waste-gate (Figs. 33 and 34 and Plate CXXIX) are quite typical.

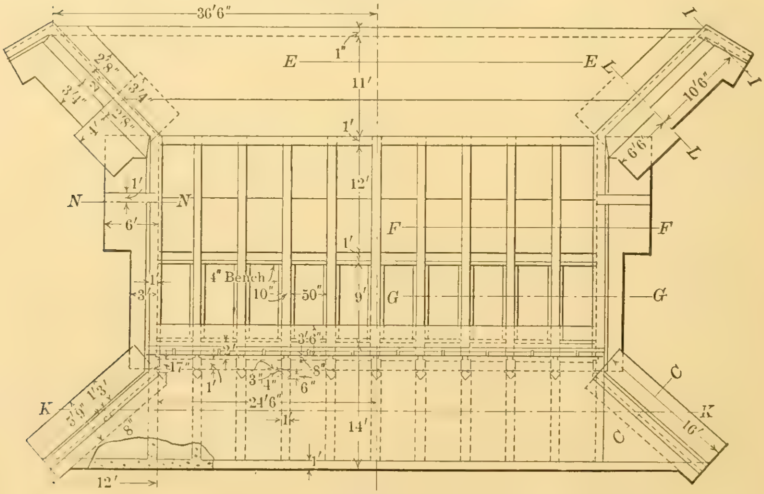
ROSITAS WASTE-GATE



SECTION *K K* AND ELEVATION OF GATES



ELEVATION LOOKING UPSTREAM



PLAN

FIG. 33.

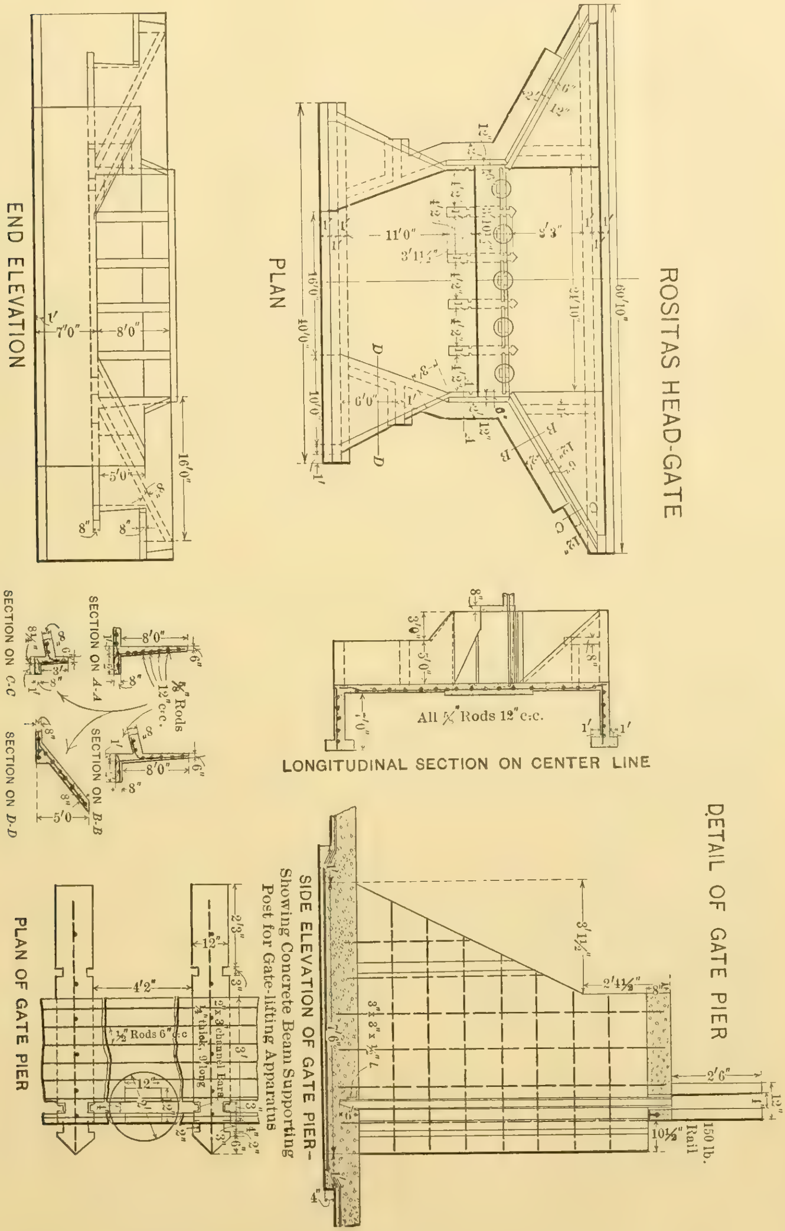

ROSITAS HEAD-GATE
PLAN
END ELEVATION
LONGITUDINAL SECTION ON CENTER LINE
All ⅝" Rods 12" c.c.
SECTION ON A-A
SECTION ON B-B
SECTION ON C-C
SECTION ON D-D
⅝" Rods 12" c.c.
DETAIL OF GATE PIER
SIDE ELEVATION OF GATE PIER–
Showing Concrete Beam Supporting
Post for Gate-lifting Apparatus
PLAN OF GATE PIER
½" Rods 6" c.c.
2"x 3" channel Bars ¼" thick, 9' long
3"x 3"x ½" L
150 lb. Rail
60'10"
21'10"
40'0"
16'0"
10'0"
11'0"
7'0"
8'0"
5'0"
6'0"
4'2"
3'1½"
3'½"
2'4½"
2'6"
2'3"
10½"
12"
8"
6"
1'
D
D
B
B
C
C

FIG. 34.

The Rositas Heading and Waste-gate cost $55 250, and the Seven-Foot Drop, together with the little gates which constitute one structure, cost $23 750. Concrete work, generally, has cost about three times as much as wooden structures; it has ranged from $30 to $35 per cu. yd. for the entire cost of completed structures.

Maintenance and Operation.—Until such time as the promised arrangements for river control and levee maintenance by the Government should be fulfilled, the operations of the irrigation interests, under instructions from higher authorities, were made to include levee maintenance and extension as well as supplying water in wholesale to the mutual water companies. The business done by the corporations was in this way much more varied than that of most irrigation companies, although none of the land they owned was under cultivation.

Because of the litigation which seemed inevitable, and indeed which had started ere this, it was deemed essential to have a complete and satisfactory system of accounts. Inquiries were directed to all possible sources of information, including the U. S. Reclamation Service, to discover a system of irrigation accounts similar in a general way to the system of railroad accounts generally adopted and for some time past made obligatory by the Interstate Commerce Commission. No such system was found. The U. S. Reclamation Service has a fairly satisfactory system of construction accounts, but its work, as yet, is almost exclusively construction.

The accounting system, therefore, was worked out, modeled closely after the classified railroad accounts. The account numbers of the Mexican Co. are the same as those of the C. D. Co., except that one thousand is added. Four years' experience with it has resulted in few changes, and in its present form it is extremely satisfactory. Lack of space forbids giving it in full, as there are 146 expenditure and 16 revenue accounts.

In order to ascertain the cost of particular portions of the work—whether new construction, betterments, or ordinary maintenance—special accounts are kept as desired, such as General Manager's Orders (G. M. O's). A G. M. O. is asked to secure authority for, or to secure cost figures on, any particular piece of work, and they are numbered consecutively, beginning with 1 for the C. D. Co. and 1 001 for the Mexican Co. The classified accounts and the G. M. O's are entirely independent, the latter being really a second and additional accounting

PLATE CXXIX.
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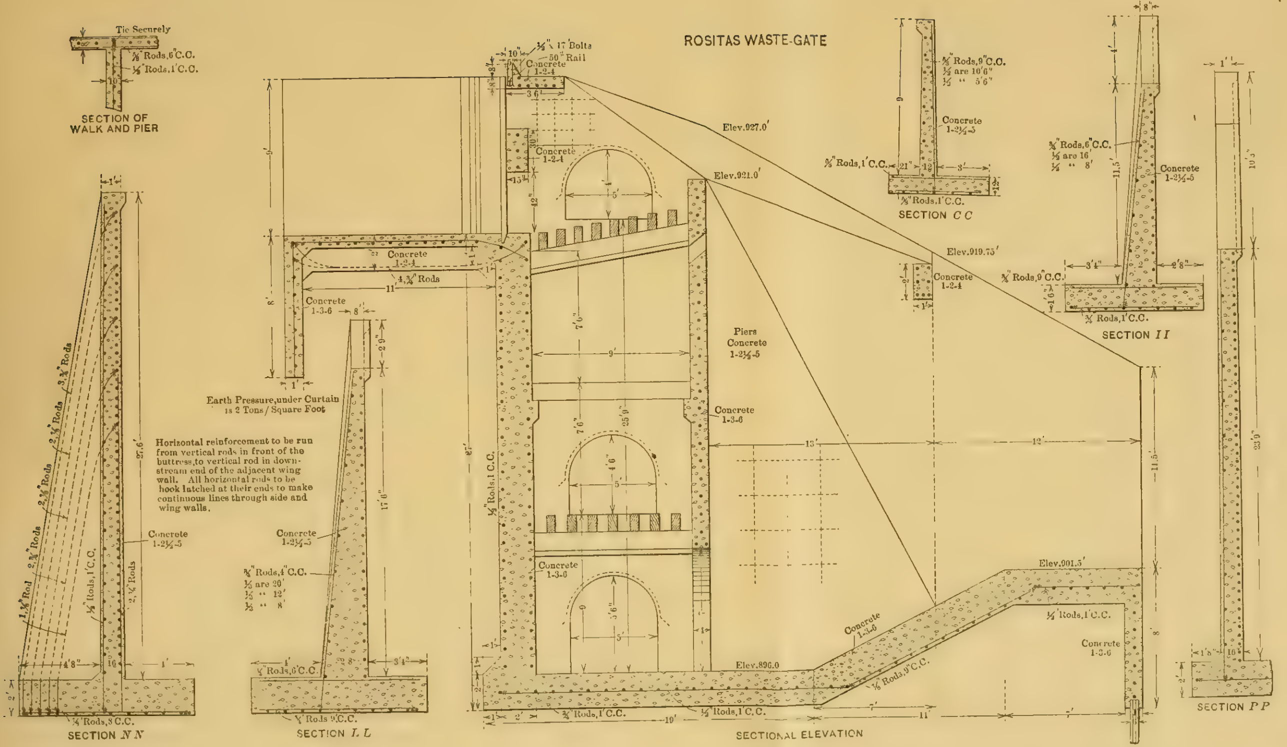
ROSITAS WASTE-GATE



SECTION OF WALK AND PIER

SECTION *N N*

SECTION *L L*

SECTIONAL ELEVATION

SECTION *C C*

SECTION *I I*

SECTION *P P*

for the same expenditure. G. M. O's were never asked for expenditures of less than $300, and were required for all expenditures of certain kinds specified in bulletins issued from time to time.

Distribution was made both to account numbers and to G. M. O. numbers on all payrolls, material requisition blanks, vouchers paying contractors, etc. The auditor's office gathers these figures and makes a monthly report, to the general manager and to the chief engineer, of the expenditures under each account number, totaling under headings. A similar report, of the receipts, under account letters, with totals, is furnished to the general manager. A monthly statement is made up and sent to the general manager and the chief engineer concerning each G. M. O., giving a statement of original estimate, amount expended to date, and percentage completed. Whenever work covered by G. M. O.'s is materially changed, a new G. M. O. is gotten out accordingly.

With such accounts, occasional trips of inspection, to observe the physical condition of the system, will afford a very complete knowledge of the exact condition of the project at all times.

The relationship between the C. D. Co. and the various mutual water companies was at all times very satisfactory and cordial, until the former was thrown into the hands of a receiver, there being one exception, however, in Imperial Water Company No. 5. Differences antedating the beginning of the railroad management and in a large measure due to dissensions between former President A. H. Heber and his Board of Directors, resulted in commencing litigation to compel Imperial Water Company No. 5 to pay up back water rentals. The attorneys of the latter company, in their cross complaint, attacked the validity of the mutual water company and water stock plan of a water right. The suit was before the United States Circuit Court, and in rendering the decision the judge expressed the opinion that the plan was illegal, and, practically speaking, the C. D. Co. was a public service corporation. This was but an opinion, because the State Courts of California have to decide this question finally, as it is a matter of the Constitution and Statutes of the State of California exclusively. The effect of this opinion, however, was to make the Southern Pacific Company feel that it would be unsafe to advance the large sums of money needed to reconstruct and extend the system on the expectation of being repaid ultimately through the sale of additional water stock to cover the new territory which would be brought under the canal. This suit, as much as any other factor, is responsible for the fact that practically nothing has been done on the betterment and extension work outlined. This litigation with No. 5, although begun in August, 1906, has not yet reached a definite conclusion.

When Imperial Water Company No. 1 was organized, the capital stock was placed at 100 000 shares, and the territory embraced within its limits was 35 000 acres. Of the excess land, a large part was found to be well worth reclamation, so that early in 1910 no No. 1 water stock was available. Imperial Water Company No. 1 was unwilling to increase the capital stock without obtaining from the C. D. Co. a contract increasing the quantity of water it would be entitled to demand and so retain the basis of a 4 acre-ft. per annum per share of stock. It was impossible for the mutual water companies and the C. D. Co. to agree as to the proper division of the "water right" receipts for such 35 000 acres, so no relief was afforded to *bona fide* settlers who had their land ready and had to have water or lose their filings under the rulings of the U. S. Land Department. A trial suit was instituted, known as Thayer *vs.* C. D. Co., which was decided in favor of the plaintiff on March 17th, 1911, by Judge George H. Hutton, of Los Angeles, sitting for Judge Cole in the Superior Court of Imperial County. Judge Hutton in brief decided that the C. D. Co. was a public service corporation; that the rate for supplying water was 50 cents per acre-ft.; that the C. D. Co. was in a position to supply the plaintiff without detriment to the other water users; and ordered that it do so. This decision has been appealed to the State Supreme Court. If it is upheld, the mutual water company will not be a necessary factor in obtaining water from the C. D. Co. This decision has not affected the price of water stock in the valley very materially, because the various mutual water companies own the distribution systems, and the difficulties of getting water from the short mileage of the C. D. Co. main canals through other sources than the distribution systems of the mutual water companies are practically prohibitive. The decision, of course, absolutely precludes extension of the irrigated area any farther through such a water stock plan.

It is very unfortunate that a clause in all the triparty contracts requires the actual seepage and evaporation from each mutual water company's distribution system to be made after a period of 3 years, and that the percentage allowance thus determined should thereafter be made, to the end that the mutual water companies would pay for the quantity of water which could actually be delivered to the individual settlers. All the mutual water companies joined and selected an engineer, Mr. F. S. Scobey, to represent them in making seepage and evaporation determinations, and did quite a little experimenting and investigating. The engineers of the C. D. Co. also made numerous determinations under the direction of Mr. Herrmann, but for various reasons no experimentation was done jointly. The amount of work and expense involved greatly surprised the representatives of the mutual water companies, and proposals of a compromise were made, one thing helping to this being that such representatives agreed that it would be distinctly unsatisfactory to have different percentages agreed on for each of the mutual companies, as must obviously be the result. The C. D. Co. was thrown into the hands of a receiver just as these negotiations were reaching conclusion on the basis of 6% flat allowance. In the confusion following, the companies insisted on a 10% allowance, and this is the present status.

The results obtained by Mr. Scobey have never been given out, but the experiments by the engineers of the C. D. Co. showed a surprisingly small loss. It appears that the very fine silt deposited in the distribution systems of the various mutual companies forms a practically impervious coating on the sides and bottom, the measured loss in many cases being as small as 0.25% per mile and increasing to a maximum of 1% per mile. From the available experimental data, computation of the losses from the distribution system of Imperial Water Company No. 1, comprising nearly 375 miles of canals, gives the total for seepage and evaporation throughout the year, under present operating conditions, as somewhat less than 7 per cent. The writer has no knowledge of so small a loss by seepage being reported by any authority heretofore.

The experience has been that the mutual water company plan of organization to distribute water, obtaining it from a larger company at wholesale, is highly satisfactory, and it is commended for careful consideration by those who are contemplating irrigation work, if the local laws will permit.

As far as the physical maintenance of the canal system is concerned, it may be said that the average life of the redwood structures, consisting of checks, drops, turn-outs, waste-gates, etc., is about 5 years for the smaller structures and 8 or 10 years for the larger ones. It must be remembered that water is used every day in the year, so that this experience has narrow application. The chief deterioration is caused by a sort of dry rot beginning about 1 ft. below the surface of the ground and extending down not more than 2½ ft. It appears that deeper than that, regardless of the quantity of water present, the heat does not become great enough to cause trouble, while the upper layer of earth is nearly always so dry that the wood is not attacked. In the thin intermediate layer, which is both damp and hot, and perhaps where enough oxygen is available, dry rot appears very rapidly, and wood wet on one side and in contact with earth on the other has the earth side damaged to a depth of from ¼ to ¾ in., sometimes in 9 or 12 months. Redwood subjected to several kinds of treatment has been tried, but with little success. Oregon pine, for that portion of structures covered by earth in that region, rots very rapidly indeed.

The chief lesson taught by the maintenance of the canals—other than that the cost is unusually large because of tule growths and silt—is that inside berms must be avoided and when possible all canals except the sub-laterals should have a double or twin cross-section. In the Imperial Valley the absolute minimum quantity of water is approximately 25% of the absolute maximum—a very unusual condition of affairs. If the sections are identical, it is possible to use one canal for a long time, and have it never less than one-half full, and consequently the velocity of the water is never low enough to deposit the finer silt. This allows a sufficient time for cleaning one canal and then the other every year. When the demand increases beyond the capacity of one canal, both channels are more than half full. In this region, therefore, it is possible with the twin section to control the velocity between the excessive silt-depositing lower limit and the bank-erosion upper limit with absolute certainty. The additional construction expense of the canals for the twin section is much more than justified by the very greatly reduced maintenance charges thereafter.

Duty of Water.—As a basis for estimating the quantity of water required under the Yuma Project, investigations were made, under the direction of the University of Arizona Experiment Station, to determine the water required for various crops in the Yuma Valley. As a result of this work, it was decided that for the average 40-acre unit, 5.8 acre-ft. per annum, measured at the delivery box at one corner of the field, would be required. Such a figure is exceedingly interesting, but was not obtained under the usual operating conditions. Indeed, the satisfactory delivery of water has been made so recently and in such relatively small quantities in the Yuma Valley as not to justify any definite conclusions.

Water has been actually used in irrigation in Imperial Valley for more than 10 years, and although there seems to be no reason why the duty of water there should not be essentially the same as in the Yuma Valley, the quantity used in the former is only about half as much as indicated by the experimental work mentioned.

The crop census taken by the Zanjeros of Imperial Water Company No. 1 for that district during 1911 is as follows:

Alfalfa	44 262	acres
Barley	28 897	"
Corn	12 034	"
Cotton	6 263	"
Melons	2 153	"
Vineyards	1 352	"
Truck	1 092	"
Asparagus	192	"
Miscellaneous	3 327	"
Total	99 572	"

To supply this acreage, the company bought from the C. D. Co. during the period 274 665 acre-ft. of water, or an average of almost exactly 2¾ acre-ft. per acre under cultivation. This is net, after deducting the 10% seepage and evaporation allowance given by the C. D. Co., as already explained. Of this net quantity, according to the water company's report, 92.3% was delivered and charged to the stockholders, making the average quantity of water used, measured at the farmers' boxes, 2.538 acre-ft.

The quantity of water used in irrigation depends on so very many different factors—quality of the land, nature of the crop, proper preparation and leveling of the land, and time of irrigation—that it is only by such general figures covering large areas that much tangible information for engineers is obtained. It must be remembered, however, that the water supplied is charged for on a quantity basis, which undoubtedly tends to minimize the quantity used, as well as the fact that the farmers know they can have all the water they want at any time they want it, every day in the year. On the other hand, water users—stockholders—are charged their *pro rata* of maintenance and operation expenses, regardless of whether or not they use any water, and also for a minimum of 1 acre-ft. per share of stock. Additional water is 50 cents per acre-ft.

The use of water is increasing in this district, and is in large measure due to the increasing acreage in alfalfa and cotton. The figures are:

1909	214 333	acre-ft., net.
1910	236 631	" " "
1911	274 665	" " "

The figures for other districts are not available, but are probably similar.

The Salt Works Suit.—The New Liverpool Salt Company, whose property was inundated and destroyed on March 8th, 1905, began suit for damages to the extent of $180 000 for land and salt deposits and $30 000 for plant, changing the figures to $325 000 and $75 000, respectively, when the destruction became complete. In July, 1906, a compromise was suggested on the basis of $50 000 cash, but the management of the C. D. Co. declined to consider it. On January 10th, 1908, the case was decided, awarding the Salt Company $456 746.23 damages and $1 500 costs, and a permanent injunction was issued restraining the irrigation companies from diverting more water from the Colorado than would supply the substantial needs of the people residing in the valley. Later, the United States Supreme Court affirmed the decision.

Actions of the Southern Pacific Company.—When this adverse and excessive judgment had been rendered, it was seen that the United States Courts would hold the C. D. Co. liable for all damages caused by the diversion of the river, regardless of the fact that it had occurred in Mexico. All personal property and unsold water stock, therefore, was turned over to the Southern Pacific Company at fair prices, and future payments for water rentals were assigned to the Southern Pacific Company until the moneys loaned by it should have been repaid. At the same time, suit was brought in the United States Court for damages sustained in America, and suit was filed in the Mexican Courts for damages sustained in both Mexico and the United States, and all real property in the respective countries was attached. The suits in the United States are still pending. Judgment was rendered in the Mexican Courts for $900 000, gold, against the Mexican Co., and enough property of that company was ordered to be sold to satisfy this judgment. Another Mexican corporation was formed by the Harriman interests, and permission to hold the concession of the original Mexican Co. was obtained from the Mexican authorities. At the sale, held on January 28th, 1911, this new Mexican Company bid in all the real and personal property of the Mexican Co., including the concessions from the Mexican Government, for the sum of $325 000, gold, which was less than 40% of the judgment. Thus nothing now remains of the original Mexican Co. except the organization, with a $575 000, gold, judgment against it, and additional suits aggregating nearly $2 000 000 in the Mexican Courts, and absolutely no property.

The new Mexican Corporation, called the Lower California Land and Water Company, owns practically all the parent irrigation company's holdings in Imperial Valley having any value, but has not yet taken possession. Shortly after the sale by court decree, fraudulent dealing was alleged, and on November 18th, 1911, it was advertised that the Judge of the First Instance at Mexicali, would hear any and all complaints in the matter. No one appeared, and it seems probable that the validity of the sale must therefore be confirmed. In that event, the new company will be free of any contracts with the mutual water companies, the C. D. Co., or any one else, and is probably quite beyond the reach of the American Courts. This, however, means little to the water users living in either the United States or Mexico, as the Mexican Government has issued rules and regulations by which water must be sold under the Mexican concession, and these fix the price at 50 cents per acre-ft., and practically in no wise affect the conditions under which American users now receive water.

The C. D. Co., in that event, would be a mere shell; it owns only 65 miles of main canals which produce no revenue whatever, cost no little to maintain, and are hence liabilities instead of assets; it also owns its office, grounds, and buildings, all of which are under attachment, and its liabilities exceed $2 000 000.

Appointment of Receiver.—On December 16th, 1909, the Title Insurance and Trust Company, trustees for the bond issue of the C. D.

Co., applied to the Superior Court of Imperial County to declare the C. D. Co. insolvent and appoint a Receiver, which application was granted. The Southern Pacific Company has bought approximately $325 000 worth of Receiver's certificates, which, together with the major portion of the water rentals received from the mutual water companies, has kept the property going. Application has been made to sell the property, but this has been delayed as long as possible by the attorneys representing the bondholders, the New Liverpool Salt Company, and the old stockholders of the C. D. Co. In a few months, however, it seems probable that this will be accomplished.

Formation of Imperial Irrigation District.—Because of the various difficulties and the serious litigation, the people of Imperial Valley, on July 14th, 1911, by a vote of 1304 to 360, elected to form the Imperial Irrigation District. According to the present law of California, this district can condemn property, even of a public service corporation, and all taxable property within the district is assessable for its needs. It is authorized to incur a bond issue of 50% of the assessed valuation of the property of the district, and the five directors are elected by all voters in the district just as in the case of county and State officials. The assessed valuation of Imperial County this year is $16 161 923; the value of its products is $10 000 000.

It is intended to acquire all the property of the C. D. Co. and the main canals and works in Mexico, giving bonds of the Imperial Irrigation District in exchange therefor. It has not been decided definitely whether the mutual water companies are to be retained, or whether the district is to own and control the entire water system—probably the former will be done.

The present law of California, under which this district was formed, is extremely interesting to water supply and irrigation engineers. It is a considerably changed form of the Wright Irrigation Act, under which, some 20 years ago, a number of irrigation districts were created in California, all of which resulted disastrously. It is believed that in its present form the law is a practicable one, and experience with it will be awaited with much interest.

THE ABEJAS DIVERSION.

The excessive overbank flow during the summer flood of 1907 started cutting back fingers, as has already been stated. The flood of 1908 continued the work, and made it evident that the deep finger which first would have its grade receded to and through the bank of the Colorado, and thus again divert the entire river to the west, was one of the feeders of the Abejas, and that such diversion would occur about 20 miles below the International Boundary Line.

The situation was carefully watched, and the various interests affected were fully advised of developments. The United States Government had taken no tangible step to repay the moneys expended in closing the second break and in subsequent levee protection work, nor anything definite whatsoever with the Mexican Government looking toward a joint and satisfactory control of the situation. All interests, nevertheless, seemed to feel that the Southern Pacific Company would advance funds to protect the valley when a critical stage should be reached. The writer, in local charge of the situation for that company, had become fully convinced that the truest and best interests of all concerned would no longer be served by the railroad company standing in the breach, and recommended doing absolutely nothing further in protecting the valley than to maintain the existing levee system. In almost everything there comes a time to decline longer to carry the entire load. This recommendation was approved by the higher officials. When the summer flood of 1909 had passed, the expected diversion was an accomplished fact, and as a result the entire low-water flow followed through the Abejas, spread out in a wide sheet without any defined channels, gathered into Volcano Lake and Hardy's Colorado and thence reached the Gulf.

The water in the river at the break dropped somewhat, and, as the river fell to its low-water stage, the water surface for a given discharge was found to be unusually low. The reasons for this have already been explained, but were not then fully understood. The demand for water in the valley increases greatly late in January, on account of the barley crop, and a serious water shortage seemed very probable.

Submerged Weir.—On urgent representations to the War Department, backed by the recommendation of the Reclamation Service engineers, permission was granted in March, 1910, to build a temporary obstruction in the river opposite the concrete head-gate, in order to raise the water a few feet and increase the flow in the canal. Work was started, but the river began rising and rendered it temporarily unnecessary. When the summer flood receded, in July, the situation was again critical, due to the large requirements in the valley, and work was resumed.

A trestle consisting of 4-pile piers, 15 ft. from center to center, was driven across the river at an angle of about 70 degrees. On this a railroad track was laid, and a little brush and considerable rock was dumped therefrom. Of course, there was no difficulty in developing a head of 2½ ft. This weir or obstruction prevented any danger of water shortage in the valley, but, not being square across the river, it produced eddy currents, just below it on the Arizona side, which cut away the bank to some extent and necessitated considerable expense in bank protection work.

The permission of the Government was given for this construction, on the understanding that it was to be temporary, and would be removed before the next spring flood. In March, 1911, all the piling was blown off, not pulled.

Late in 1910, arrangements were made to obtain the large suction dredge, *Imperial,* and with it in service no further immediate difficulty in diverting sufficient water is anticipated.

A very important fact, however, was developed in the construction and attempted removal of this weir, namely, that the small quantity of rock dumped from the trestles which was required to raise a head of 2½ ft. at low-water stages—about 10 000 sec-ft.—was not undermined and did not settle except to a slight extent in a few places, with the summer floods of 1911 and 1912. These floods were ordinarily large, and, passing over it, had little effect in taking it away. This result was surprising, even to the proponents of rock fill methods of building weirs. The length of time it finally requires to eliminate all effects of this weir from the river flow at that point should be kept track of and reported to the Profession from time to time.

All Parties Frightened.—All the interests in jeopardy were now thoroughly frightened. It was finally realized that the Southern Pacific Company would no longer supply money for river control, and that the diversion was not only an accepted fact, but that the prophesied lowering of the river at the concrete head-gate had taken place. The fear had been that the bed of the river would be lowered at the Abejas break approximately from 5 to 8 ft. and that this lowering would rapidly run back up the river and have such an effect opposite the concrete head-gate as to prevent diverting enough water to supply the needs of the valley. This fear is now known to have been in large measure unfounded, as the permanent lowering of the water surface at the Abejas probably has not been more than 2 ft., and opposite the concrete head-gate not more than 1 ft., if, indeed, that much at either place.

Another fear was that the Colorado would now discharge directly into Volcano Lake, and during severe flood periods raise this body of water so high that it would flow northward and into the New River channel, thus cutting back a connection, permitting the river again to reach the Salton Sea, but by a course approximately 40 miles longer.

As the summer flood came on, the overflow covering the low lands on each side of the Abejas, especially in the vicinity of Campo Lino, was higher than any existing marks on trees, etc. To prevent this water from getting over the low divide to the north and thence to the Salton Basin, disconnected portions of the remaining gap in the levee line were partly built, the C. D. Co. through its Receiver paying the bills. While the work was in progress, the water, for long stretches, came within a few inches of the top of the fill being thrown up, and was held south of the divide only by strenuous efforts. Probably no very serious results would have followed in any event, although the New River flume of the West Side Main might have been damaged.

The people of Imperial Valley were now thoroughly frightened, and urgent applications were rushed to President Taft, in which the civic and commercial bodies of California, especially Southern California, and the State officials joined. These applications pointed out the inability of American interests in jeopardy to handle a menace originating in Mexico, and the injustice they suffered.

In response to these applications, President Taft sent a special message to Congress, and on the eve of adjournment the two branches of Congress joined in a resolution, approved June 25th, 1910, providing:

> "That the sum of $1 000 000, or so much thereof as shall be necessary, is hereby appropriated out of any money in the Treasury not otherwise appropriated, to be expended by the President, for the purpose of protecting the lands and property in the Imperial Valley and elsewhere along the Colorado River, within the limits of the United States, and the President is authorized to expend any portion of such

money within the limit of the Republic of Mexico as he may deem proper, in accordance with such agreements, for the purpose, as he may make with the Republic of Mexico."

On June 8th, 1910, the acting Secretary of the Interior, Mr. Frank Pierce, addressed to the President a communication based on information and recommendations furnished by Mr. Hill, Supervising Engineer of the United States Reclamation Service, advising as follows:

"The ascertainment of what is necessary to be done for the purpose of accomplishing permanent avoidance of these recurring menaces to life and property on both sides of the International Boundary Line will require a thorough examination of physical conditions which, to be effective, should have the co-operation of both governments, and will consume considerable time. In the meantime, unless prompt relief is afforded, a water shortage, if not famine, is probable in the Imperial Valley within the next two months.

"In a country where the heat reaches an intensity of 120° and even higher, the great loss of property and the menace to both animal and human life which may result, should such a catastrophe occur, renders it imperative that prompt measures be taken toward averting the same. To that end, I respectfully recommend that you designate an engineer having familiarity with problems involving river control to proceed immediately with an examination for the purpose of determining whether such emergency exists, and if so, to take the steps necessary to avoid the same."

On the recommendation of Gen. W. L. Marshall, Consulting Engineer to the Secretary of the Interior, John A. Ockerson, President, Am. Soc. C. E., and for many years Member of the Mississippi River Commission, was, on July 19th, 1910, appointed by President Taft. He at once went to Yuma, arriving there on July 30th, by which time Mr. F. L. Sellew, Engineer of the Yuma Project, on Mr. Ockerson's request, had made a survey covering the immediate vicinity of the C. D. Co.'s intake, and had prepared a plat which showed clearly that the bed of the river was above the bottom of the head-gates and that the deficiency of water in the canal was due mainly to the silting up of the intake above and the canal below the concrete head-gate.

There were two possibilities: one was to get dredging machinery into place as rapidly as possible and dredge out the canal; the other was to raise the water in the river by a submerged dam, the latter being temporarily necessary because of the time required to build dredges to do the necessary work. As explained, the weir was begun in the latter part of July and completed within a month, while the contract was not let for an efficient suction dredge until late in December, the delays in starting the latter being in part due to difficulty in arranging funds therefor, and in part due to a belief in some quarters that, with the submerged weir in place, a dredge was unnecessary.

Mr. Ockerson made an inspection of the Imperial Valley during the latter part of August, and about the middle of that month put out a surveying party which ran a stadia line along the Colorado River from about 6 miles below the Boundary Line to the Abejas break; thence down the dry bed of the Colorado for about 25 miles; down the Abejas River from the point of diversion about 5 miles; and made several cross-sections of the Abejas for the purpose of selecting the best site for a rock fill barrier dam—all of which required about 6 weeks.

On October 4th, Mr. Ockerson reported to the Secretary of the Interior that the Imperial Valley would never be safe from the menace of western diversions due to flood-waters until ample works were constructed to confine such flood-waters to narrow limits along the river proper; that there had been no appreciable lowering of the river bed on account of the Abejas break; that in extreme cases diversions to the west might depress the low-water plane opposite the concrete headgate and render it difficult to supply water to the Imperial Valley with the present diverting works; that the maintenance of levees consists not only in keeping up the cross-section, freeing it from weeds, brush, and burrowing animals, but also in holding in check the tendency of the river to erode the banks and threaten to breach the levees; that a levee located 3 000 ft. from the westerly bends of the stream would probably remain intact for a long time; that if the C. D. Co. levee line had been carried down along the river instead of where it was built in 1907, it would have reached a point 6 miles below the Abejas break, and no break would have occurred there; that completing the upper levee would undoubtedly protect the Imperial Valley from floods for a short time, but constituted only a partial solution of the problem, and even that only temporarily; that, finally, the proper protection of lands in the Imperial Valley required that the Colorado River be restored to its former channel and an effective line of levees be built from a point on the existing levee system about 6 miles below the International Boundary Line and following along the west side of the stream to a distance of about 3 000 ft. from the westerly bends of the river, approximately 25 miles, where the flood height would be at an elevation below the ground line in the vicinity of Volcano Lake and any diversion of the water would not cause a tendency to flow north.

It was estimated that such a levee would require about 1 300 000 cu. yd. of earthwork and 450 acres of clearing and grubbing; and it was recommended that the top be 8 ft. wide, the slopes 3 to 1, and the berm between the toe of the slope and the edge be 40 ft. wide, and that borrow-pits be on the river side, with traverses 50 ft. wide at intervals of 400 ft.

In commenting on the situation, Gen. Marshall recommended completing the northern line of levees, as originally designed by the writer, to prevent the water from getting north, and providing a suitable and practical intake for the canals of the C. D. Co. He also suggested that, if the present intake (concrete heading) be closed and the Imperial Canal be extended to the Laguna Weir, the matter would be solved, as far as American interests were involved.

A month later Mr. Ockerson went to Washington for a conference, the result being that the work suggested by him was ordered begun. On November 25th bids for the levee construction were opened in Yuma. According to the specifications, the contractor was to assume all risks of interruption of the work by floods, and as the season was by this time far advanced, the prices were deemed too high and endeavors were made to get the work done on force account.

At about the same time it was discovered that the Mexican Government—as would naturally be expected—could not consistently permit the United States Government, or any of its officials acting as such, to perform work on Mexican soil. For six years, the need for making satisfactory arrangements and agreements with the Mexican Government regarding the Colorado River and its control, and proper and equitable division of its waters, had been fully understood, but practically no progress had been made. That fact, however, makes it even more surprising that requests on the part of the United States should have been made to enter Mexican territory and do work therein. The difficulty was very easily overcome, of course, by operating through the medium of a Mexican corporation, as the Southern Pacific had done, and the C. M. Co., which, as has been explained, is a very large land company, was chosen. Consequently, nothing was done in the name of the United States, but the engineer in charge acted under power of attorney from the C. M. Co., there being a gentleman's agreement between the United States and the C. M. Co.

In this way, on December 12th, contracts were awarded for levee construction, the first 9 miles, aggregating 425 000 cu. yd., at from 19 to 22½ cents; the next 6 miles, aggregating 336 000 cu. yd., at 23 cents; and the remainder, aggregating 325 000 cu. yd., at 36 cents. These figures were afterward considerably increased, the total quantity being 1 277 984 cu. yd., and the total cost, including $20 000 paid for duties, $452 434. The work in the immediate vicinity of the Abejas break and the small quantity of grading on 4 or 5 miles of temporary track was done by the C. M. Co. on force account. President Lovett, of the railroad company, offered to supply, essentially at cost, all the organization, men, equipment, and supplies required for closing the break and for doing any other work that might be deemed necessary.

The Mexican Government had given assurances to the American Minister that duties on stock, material, and supplies would be remitted, which was considerably more than had been done when the railroad had the work in charge. The Government officials, however, were not satisfied with this, and thought that all material should be passed free—a matter very much more difficult to arrange under Mexican laws, as it would require Congressional action, and that country was already in the throes of a revolution. However, after a delay of 2 weeks in getting stock across the line, it was decided to arrange for the duties and depend on a refund later. The contractors began work early in January. At about the same time one pile-driver was put to work on a trestle across the Abejas, and by February 2d (river discharge, 11 000 sec-ft.) the temporary track was completed to and over the trestle, and rock dumping began.

The method was that developed in closing the first and second breaks, and used later in closing the gap in the Laguna Weir, one trestle being deemed quite sufficient, as the maximum head was not expected to exceed 7 or 8 ft. At the Andrade quarry there were approximately 15 000 cu. yd. of rock ready to load with steam shovels, and the quarry was well developed, having a face about 900 ft. long and averaging 40 ft. high. Two 4-cu. yd. steam shovels were secured from the Southern Pacific Company, and a 2½-cu. yd. shovel of the Reclamation Service was brought down from the Laguna Weir. Work trains, men, and "battleships" were obtained from the railroad, as required, and rails and track material were furnished on a rental basis.

On February 7th, a sudden rise (maximum discharge, 23 000 sec-ft.) caused a breach in the trestle; this was closed 10 days later. On March 7th another small rise in the river carried away seven bents, and 6 days later another rise (maximum discharge, 35 000 sec-ft.) brought down a mass of drift and wrecked a considerable length of the bridge, caused the loss of a pile-driver and one steel "battleship," and drowned one man. On the 28th the pile-driving was resumed and the operations were continued without further mishap until May 15th, when work on the dam was shut down.

In making this closing, the rock fill was not kept at uniform height for the entire length of the trestle, the overpour for some of the time being confined to three places with a total length of from 260 to 275 ft. It is probable that this explains in large measure the breaking of the trestles by floods and drift, after obtaining an effective rock mattress, such as is provided by dumping two or three cuts of "battleships" all along. In building the Clarke Dam, floods (maximum discharge, 32 000 sec-ft.), with heavy drift, threw the trestle out of line in only one place after rock dumping began, and caused no other damage.

The number of cars unloaded in the Abejas closing work is given in Table 22.

TABLE 22.

Period.	"Battleships."	Flats.	Dealey.	Dinky.
January 17–31	83	....	....	12
February 1–10	314	....	....	....
" 11–20	350	5	....	....
" 21–28	616	....	....	34
March 1–10	181	....	....	....
" 11–20	108	....	....	....
" 21–31	207	....	....	108
April 1–10	747	43	....	20
" 11–20	781	40	6	....
" 21–30	581	70	37	....
May 1–2	41	3	....	8
Totals	3 996	161	43	182

The total quantities were: 139 860 cu. yd. of "battleship" rock, 193 cu. yd. of flat-car rock, 516 cu. yd. of Deelez rock, and 1 092 cu. yd. of quarry rock in dinky cars, a total of 143 400 cu. yd. up to May

2d. The total quantity of rock used to May 15th, when work closed down, was about 180 000 cu. yd. The total cost of the dam is given as $347 500.

About 140 000 cu. yd. of rock were used before the water was practically shut off in making this closing. The reasons for requiring such a large quantity probably are that relatively little flat-car rock of large size was used, the fact that the rock fill was not carried along at a uniform height for the entire length of the overpour, and the slow rate at which the rock was unloaded. The first methods of quarrying were not well adapted for giving the maximum output, consisting of operations along the top of the rock mass by the edge of the quarry face, but, later, horizontal tunnels were driven into the quarry face at intervals along the bottom and large charges of explosives were used, after which the output was much increased.

The levee work went along very rapidly, the contractors fortunately encountering no flood difficulties or delay, and on April 7th the last of the grading outfit left the work.

While operations were in progress, the Revolution in Mexico began, and resulted in the abdication of President Diaz. On February 21st, the Revolutionists captured Algodones. On April 16th a large body of Mexican Federal troops arrived at the break and remained guarding the work from interruption until May 10th.

Damage to the Work.—The 24.6 miles of levees were constructed in accordance with the recommendation, namely, with a top width of 8 ft., side slopes of 3 to 1, borrow-pits on the river side 400 ft. long, with intervening uncleared traverses 50 ft. wide, a berm width of 40 ft., the entire ground covered by the levee and the berm cleared, and roots and stumps grubbed, and a muck-ditch, of such depth as would reach through the adobe soil under the construction, dug out and filled with good material under the axis of the levees. Except for a very few cases of logs and brush in the levee section, and inefficient muck-ditching reported to have been disclosed where the levees were broken, the dikes were very well constructed in accordance with the specifications. The levee was built to a grade of "5 ft. above the high-water marks of the 1909 summer flood," chiefly for the purpose of having excess material wherewith to remedy deterioration, rather than through any fear of overtopping from floods." No railroad track or gravel blanketing was put on the levees, because of the belief "that it would be better to extend the levees as far as practical, rather than dissipate available funds for mere convenience of maintenance."

A low levee was built along the south side of the break, extending from the dam a short distance up stream, to prevent water from getting into the levee borrow-pits until the grading outfits had finished work in the vicinity. As the water in the river was gradually raised, partly by increased discharge (total, 19 000 sec-ft.) and partly by increasing the height of the rock fill across the break, this low levee was, on April 21st, overtopped and almost at once about 1 000 sec-ft. of water started down the borrow-pit clearing, about 2 000 sec-ft. going into the old Colorado River channel. When the water hit the uncleared traverses it cut the berm and side-swiped the levee at almost every traverse for several miles. Work on the rock fill dam was stopped, and the men were set at work protecting the levee. Later in the day this was stopped, and work on the dam was resumed. The latter was facilitated materially by the waters breaking over into the borrow-pits, the elevations of the water surface above and below the dam being quickly changed from 79.6 and 71.6, respectively, to 78.6 and 71.0, the depth of overpour being reduced 1 ft. and the head on the structure 0.4 ft. By dumping rock and filling the holes where the confined overpour occurred, the situation there was soon in hand, and 8 days later (April 29th) the elevation of the lowest point of the dam was 80.6, or 1 ft. higher than the water surface up stream, where the water broke into the borrow-pits, and the flow over the structure was stopped.

By that date the levee to the south was cut entirely through in several places in the first 6 miles, and it was evident that the water would soon merely detour around the dam and continue to follow the Abejas channel below. The river discharge then was 21 900 sec-ft., and about 4 000 sec-ft. were going down the old channel, the remainder running through the levee breaks and toward the west. On May 7th, the discharge of the river had increased to 32 800 sec-ft., of which perhaps 9 000 sec-ft. were running down the old channel of the Colorado, while the water varied in height from 4.3 to 6 ft. below the top of the levee in the 2 miles immediately north of the dam.

The rock fill was then up to the track all across, and the total percolation through it was reduced to about 120 sec-ft. The eddy currents below the dam, 9 days later, weakened the earth fill about 300 ft. from the north end of the dam, until the water broke through, and in a few hours the entire discharge of the river (except a little overbank flow) was going through it and down the Abejas. Soon the earth fill on the south was cut through, and thus the rock fill dam was made an island in the Abejas channel, which is the situation at present.

The final injury on the levee work prior to the summer flood was three breaks and several places side-swiped on the north levee, totaling about 16 000 cu. yd., and thirteen breaks, varying from a few hundred feet to more than 2 miles in length, and much side-swiping in the first 8 miles of the south levee, totaling about 200 000 cu. yd., or about 50% of the original earthwork in this stretch. The fact that such injury was caused by so small a quantity of water reaching a maximum depth of only 4 ft. on the levee shows clearly the ease with which the material of the region is eroded.

The protective measures used were sand bags and brush placed to check erosion and the dynamiting of the traverses which, with the drift their vegetation caught, deflected the water to the levee section. The latter procedure had the bad effect of converting the borrow-pits into a continuous canal, but with severe eddy currents caused by the remains of the traverses. These endeavors had little effect; indeed, to hold long stretches of embankment against such action is practically impossible.

On June 1st, Mr. Fisher, Secretary of the Interior, called a Board of Review consisting of Mr. F. H. Newell, Director of the U. S. Reclamation Service; Gen. W. L. Marshall, Consulting Engineer to the Secretary of the Interior; J. B. Lippincott, M. Am. Soc. C. E., formerly a Supervising Engineer of the U. S. Reclamation Service and now an Assistant Engineer of the Los Angeles Aqueduct; Mr. C. E. Grunsky; Mr. J. A. Ockerson, Engineer in charge of the work; and Gen. Harrison Gray Otis, President of the C. M. Co., to report on the work done under the appropriation. All the members of the Board, excepting Gen. Marshall, have examined the territory and understand the situation fully, although none of them except Mr. Ockerson has been on the ground since the Abejas diversion occurred.

On June 7th this Board made a report based on information as to the recent work done and results obtained, supplied by Mr. Ockerson, and answering specific questions submitted by Secretary Fisher. The full text of this report is as follows:

"1.—A breach in the west bank or levee of the Colorado River, if made at or within a mile south of the California boundary, or south of Mile 18, below Yuma Bridge, will result in water flowing directly into the drainage areas of the Alamo and New Rivers and thence into Salton Sea, which would be disastrous to property in the United States.

"2.—A breach in the river bank at any point between Miles 18 and 55, below Yuma Bridge, will result in spreading water over the Delta of the Colorado River, with a flow into New River *via* Volcano Lake, menacing Imperial Valley.

"3.—(*a*) The best practical method for the protection of land and property in the United States against a discharge directly into the Imperial Canal and thence through Imperial Valley into Salton Sea, is to protect and maintain the levees as at present located for a distance of at least 10 miles south of the California boundary and to hold the river by adequate bank revetment practically on its present alignment. (*b*) This levee, if extended to a point opposite the south boundary of Arizona, or about Mile 27, will also prevent a discharge directly into the Paredones.

"4.—(*a*) As a remedial or precautionary work to prevent damage which might result from a crevasse directly into the Imperial Canal or Alamo River, we have considered a secondary levee west of the river levees, across Imperial Canal, and large channels leading to the natural depressions, or diverting works, conducting the water southwesterly into channels leading into Volcano Lake, but it is believed that the cost of any such secondary defence could be better expended in maintaining the main line of defence at the river. (*b*) As a necessary defence against the northerly flow of any water reaching Volcano Lake, whatever be the treatment of the Lower Colorado River, there should be an embankment well protected against wave wash on its south slope, constructed about on the line of the levees already built extending from high ground north of Volcano Lake to a connection with the levees already built by the California Development Company, southwesterly, toward this region from the Colorado River. The top of this embankment should at its western end be not less than 10 ft. higher than the rim land at Volcano Lake. This embankment is an essential requisite as a protection of Imperial Valley, against menace from the south, and should be constructed without delay.

"5.—(*a*) The maintenance of the works constructed in 1906 and 1907, closing the breaks of the Colorado into the Alamo, and the maintenance of these and of the river levees since constructed as far south as the head of the Abejas are essential requirements. Suitable arrangements for their repair and maintenance should be made with

Mexico through the proper authorities. We do not consider the immediate closure of the break into the Abejas and the reconstruction of the levees below the break as essential to the protection of property in the United States. The ultimate treatment of this section of the Colorado River in co-operation with Mexico may well be determined by negotiations between the governments of the two countries. As a feature of the permanent solution of the river problem it is desirable that the Abejas break be closed, that the levee constructed in 1911 be repaired and maintained, and the Colorado River restored to its former course. (*b*) Provided the water of the Colorado is discharged into the Gulf of California through the Abejas into the Pescadero and Hardy Rivers, there is little probability of the cut back affecting the Laguna Dam. Such cut back will not injuriously affect the heading of the Imperial Canal or levees adjacent thereto, with a possible exception of requiring the lowering of the intake of the Imperial Canal a few feet. This is not a serious matter, and is one that should be dealt with by the California Development Company itself when necessary. The diversion by the California Development Company should be facilitated during low-water stages by dredging, or by lowering the sill of its intake, rather than by placing obstructions in the channel of the river below the intake.

"In view of the existing emergencies along the Colorado River, arrangements should be made with the government of Mexico to provide for the early creation of an International Colorado River Commission, embracing in its membership both American and Mexican engineers, invested with large powers and ample authority to examine into and to submit a basis for the adjustment of all questions relating to the conservation, use, and control of the waters of the Colorado River with a view to such governmental action as shall result in a complete, just, and final settlement of all such matters at issue between the two nations. We recommend that further work should be undertaken at once and in approximately the following order:

"(*a*) The levees north of Volcano Lake should be raised, strengthened, and extended.

"(*b*) The existing levees along the west bank of the Colorado River to the Abejas should be repaired and protected. For this purpose and to meet emergencies, there should be immediately available the sum of at least $1 000 000. This sum provides only for the temporary maintenance of levees, and does not include the systematic revetment of the river banks.

"The conference ventures to suggest certain international questions which are involved and which will inevitably have to be met sooner or later:

"(*a*) The matter of the permanent protection of existing works on both sides of the international boundary line, the construction of further works, and the conditions under which the present and future projects may be carried out on Mexican soil, with the consent and co-operation of the government of Mexico for the benefit of both countries, to the end that the greatest practicable quantity of water of the Colorado River may be made available for irrigation by means of storage reservoirs and otherwise, and the least possible quantity be permitted to flow unused to the sea, and to what extent the cost of such maintenance should be chargeable to properties benefited and to what extent chargeable to either government.

"(*b*) That permanent agreements with the government of Mexico shall be entered into, having in view the just apportionment of the waters between the two countries, irrigation to be paramount to navigation.

"(*c*) The method by which either nation may acquire rights of way for canals, levees, and related works, each within the territory of the other, and the authority to maintain such works.

"(*d*) The modification of the boundary line between the United States and Mexico with a view to facilitating the solution of the entire Colorado River problem. An authoritative, just and final determination of this important question, now a matter of public discussion, will have the effect of removing existing doubts in the public mind and of settling the matter for the benefit of all concerned.

"The members of the conference desire to call attention to the fact that the plan and execution of the work accomplished during 1911 followed well established principles of good engineering. That so large an amount was accomplished in such a brief space of time, under adverse circumstances, is worthy of the highest commendation. That the restoration of the Colorado River to its former channel was not realized is chargeable to the delay in the negotiations, which prevented prompt inauguration of the work and the prosecution during the low-water season, and also to the disturbed political situation and strike which demoralized labor conditions. The members of the conference, in addition to the conclusions above reached, present also a statement of physical and related facts embodied in an abstract of the data available, and found largely in the reports of J. A. Ockerson and of C. E. Grunsky. Also in the printed hearings before a subcommittee of the Senate Committee on Claims, referring to Senate 4170, January 21, 1909."

When President Taft received the report, he sent a special message to Congress recommending the appropriation of another $1 000 000 to continue the control work, but Congress failed to comply. It is desired to call particular attention to the last part of this report containing Suggestions *a*, *b*, *c*, and *d* regarding certain international questions involved, which sooner or later must be met. These suggestions contain the crux of the entire situation, and it is to be hoped that they will be expeditiously followed out. It is perhaps desirable to call attention to the wording of Suggestion *d* regarding modification of the Boundary Line between the United States and Mexico, the suggestion being implied that the matter be taken up more with a view of putting a quietus to the proposition, than with the idea of obtaining any territory from the Mexican Government.

Surveys by the New Mexican Company.

As soon as the summer flood of 1911 began to recede, and the extent of the damage sustained by the new work was ascertained, the Harriman interests controlling the new Mexican Company deemed it wise to ascertain how effective the line of levees north of Volcano Lake would be in holding back the waters of a very large summer flood. Accordingly, three surveying parties were put out early in July under the immediate direction of Mr. Hind. The surveys were carried down the river to The Colony and as far west as Volcano Lake, much of the territory being covered quite thoroughly. The field work was completed during the latter part of September, and the data were assembled and mapped. Mr. Randolph analyzed these data and compiled a report which was forwarded to Mr. R. S. Lovett, Chairman of the Executive Board in New York City, recommending:

1st.—That the westerly portion of the Volcano Lake levee be raised and extended so as to occupy a plane 6 ft. above the then present crest; and

2d.—That an effective levee system, including a rock dam shutting off the Abejas diversion, be constructed along the river to a distance of 16 miles below such dam; that the entire levee should be blanketed with gravel; and that a railway track be laid thereon in good condition for further operation when necessary.

Mr. Lovett, on December 13th, 1911, made a formal offer to President Taft, on behalf of the Southern Pacific Company, to return the Colorado River to its original channel and to maintain the levees necessary to keep it there for one year, providing the Southern Pacific Company be repaid for the work done in 1906-07 at President Roosevelt's request, in the sum of $1 830 673.90, being the amount reported as proper under the circumstances by Mr. Grunsky in his statement to the Committee on Claims during 1908; and provided, further, that an additional appropriation of $1 500 000 be placed at the disposal of the President of the United States with which to pay the actual cost of the work to be done and the cost of maintaining it for one year, the Southern Pacific Company to stand any excess of cost over and above such an amount; that the transportation charges of the Southern Pacific Company in connection with the work should be in accordance with the arrangements in effect during the work under Mr. Ockerson's direction; and providing, further, that should the Southern Pacific Company fail to return the Colorado River to its former channel and to retain the levee for one year thereafter, then in that event the Southern Pacific Company should receive no compensation or reimbursement for the work which it would do under that offer.

This proposition was referred to Gen. Marshall, Consulting Engineer for the Department of the Interior, who, under date of January 5th, 1912, reported in substance that the work proposed should not be done either by it or by any other agency on behalf of the United States at this time, nor until the entire subject of improving the Colorado River and utilizing its water should be investigated by an International Committee representing both the United States and Mexico. The following day, the Secretary of the Interior, W. L. Fisher, forwarded Gen. Marshall's report to President Taft and approved of its conclusions, stating that the suggestions constituted the most important recommendation of the Advisory Board of June 7th, 1911, and adding:

> "I consider it of great importance that negotiations should be immediately opened and vigorously conducted with a view of arriving at a treaty with Mexico covering this subject."

President Taft, in his message to Congress a few days later, placed the whole matter before Congress without recommendation.*

Perhaps the most important information obtained by these surveys is the fact that the average elevation of the bottom of Volcano Lake is 28 ft. while the general average prior to 1907 was 17.8 ft. above sea level. In other words, the bottom has been raised 10 ft. since the Colorado began to flow directly into the lake, during which time it has discharged into it approximately 30 000 000 acre-ft. of water. The streams below, draining to the Gulf, are now normally clear, showing that most

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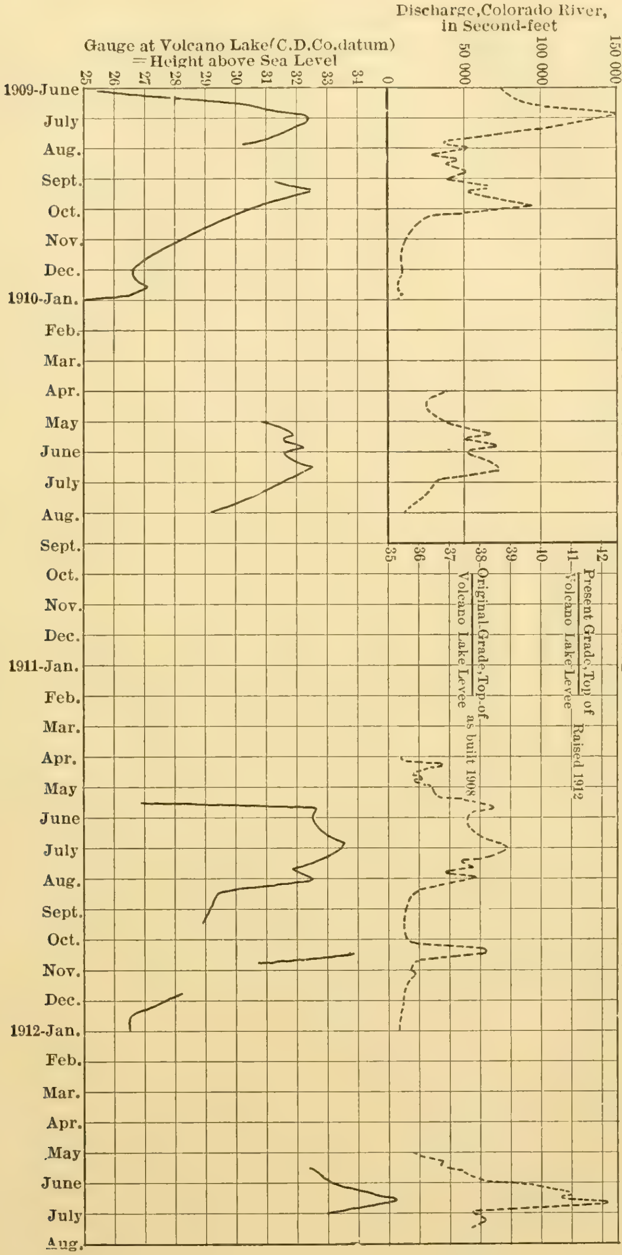
* See also House Document 204, 62d Congress, Second Session.



FLUCTUATIONS OF VOLCANO LAKE AND COLORADO RIVER 1909-1912

FIG. 35.

of the silt content of the water reaching the lake is being dropped over its bottom, together with some material eroded from the new channels formed by the diverted river. On the other hand, very much suspended material carried by the waters is let down before reaching the lake. The conditions are extreme, yet they indicate the extreme silt deterioration which may be expected in reservoirs on the Gila, Salt, Verde, Colorado River below The Needles, and similar streams.

Improvement of Volcano Lake Levee and Repair of River Levee.

Contracts were let on January 4th, 1912, for raising the Volcano Lake levee 3½ ft. and widening the crown to 12 ft., 155 000 cu. yd. at 25 cents; repairing the recently constructed levee along the river north of the Abejas break, the contract calling for 15 000 cu. yd. at 22 cents; and paving with rock the south or water face of the Volcano Lake levee, approximately 70 000 cu. yd., for $1.50 per cu. yd. This rock was obtained from the mountain sides at or near Cerro Prieto. The temporary railroad track from the C. D. Co. levee to the Abejas break was taken up, and the track material returned to the Southern Pacific Company.

Assistant Secretary of the Interior Thompson went to the City of Mexico to make arrangements whereby the Government might do this work in Mexico, but was unsuccessful. Until the United States concludes arrangements for working in conjunction with the Mexican Government, operations on Mexican soil will doubtless have to be handled in a roundabout way, particularly as long as there is fear of complaint that lawlessness interferes and delays the progress of such work as may be permitted. Mexico, however, authorized the foregoing work to be done by the C. M. Co. through the engineer assigned by the United States, Mr. Ockerson, and a gentleman's agreement was reached between that company and the United States.

Conclusion.

Because of the various successful and unsuccessful work done in the region, the engineering features of irrigation and river control along the Lower Colorado are now understood, and engineering construction methods are thoroughly developed. The successful attempts in closing breaks along the river with rock fill barrier dams according to the method developed during the first and second closings have standardized this class of work. The Southern Pacific Company can easily, on very short notice, furnish all the equipment, men, and organization needed to do all the various classes of work involved, directly or indirectly, in controlling the river. The essential features of successful levee construction there have been made very clear. The maintenance and operation of the irrigation canals involve caring for excessive quantities of silt, and sufficient data regarding the silt problem in the Main Canal have not yet been obtained to decide on the most economical method of diversion.

The Colorado River Delta now presents no unusual unsolved engineering difficulties; its problems are chiefly matters of statecraft in both river control and irrigation. At the conclusion—in the near future—of existing litigation in American Imperial Valley, irrigation of the territory will be notably free from legal and managerial entanglements. This will be as soon as, and not until, reasonable treaty provisions between the two nations are arranged. Such a treaty is indispensable for the proper handling of river control work. Fortunately, both Governments profess not only willingness, but impatience, to adjust the matter.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

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PREVENTION OF MOSQUITO BREEDING.

By Spencer Miller, M. Am. Soc. C. E.
To be Presented December 18th, 1912.

In order to promote the health and comfort of the public, mosquito breeding must be prevented as far as practicable in many parts of the United States.

Mosquitoes breed in standing or quiescent water. In the summer of 1910, a pest of common house mosquitoes invaded a city. These mosquitoes bred chiefly in the water standing in the sewer catch-basins during the summer drought. During periods of dry weather, these catch-basins are now regularly oiled, and the mosquito pest has been largely reduced. When these basins are flushed by heavy rain-storms, mosquitoes are not produced for about 10 days. Can a practical type of sewer catch-basin be constructed so that it will not breed mosquitoes?

Sewer manholes provided with a pail suspended just beneath the manhole covers have been found to be extensive breeding places for mosquitoes. Can this pail be eliminated, or if not, can it be made to drain off the water?

Engineers who direct the construction of great railroad fills across salt-marsh areas frequently neglect to provide for the adequate drainage of these marshes. The culverts which are provided are almost invariably placed too high to drain the lands sufficiently to pre-

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

vent the breeding of salt-marsh mosquitoes. The latter lay their eggs in mud, and they are hatched as soon as the mud is well flooded. Six broods of these mosquitoes (within the vicinity of New York) occur each season. Each square foot of salt marsh may breed 5 000 mosquitoes in a single brood. An acre of land contains 4 840 sq. yd.; thus, 1 sq. ft. of salt-marsh breeding area will furnish one mosquito for every square yard in an acre of land. Surely 5 000 mosquitoes to an acre must be regarded as a "pest." A square mile contains 640 acres. A pool on the salt marshes, about 25 ft. square, may supply a pest of mosquitoes for 1 sq. mile of territory; 100 000 people could live on 1 sq. mile of land. Such a pool, therefore, could breed mosquitoes enough to torment 100 000 people for six periods during a season; and, furthermore, since mosquitoes may live two weeks, these 100 000 people may be tormented for one-half the summer season. When so great a pest may proceed from so small a source, is it not the duty of engineers employed in railroad work to give full consideration to drainage facilities for the salt marshes which are being crossed?

In other ways, also, the work of engineers may be directly associated with the prevention of mosquito breeding. It was established in the City of New Orleans that the yellow fever mosquito bred most prolifically in elevated water tanks and water barrels. By the introduction of a central water supply system, these water tanks and water barrels were eliminated, and the mosquito pest was thereby largely reduced.

Cesspools are prolific breeders of the common house mosquito. The introduction of a sewer system and the filling up of these cesspools have been known to reduce largely the mosquito pest.

City engineers can order dirt taken from roads in grading to be dumped in low spots where water stagnates.

The civil engineer has an opportunity to serve his fellow men and do a vast amount of good work in the prevention of mosquito breeding, if he acquires the knowledge now available on their breeding habits.

It is not intended in this paper to review the work which has been accomplished by entomologists during the last few years. A number of pamphlets, devoted exclusively to the subject, have been published by the Department of Agriculture, and are obtainable for the asking.

Reports by State Entomologists are also frequently obtainable. Dr. L. O. Howard, Chief Entomologist of the Department of Agriculture, has published an extremely valuable book on the subject, which is obtainable from publishing houses. The late Dr. John B. Smith, State Entomologist of New Jersey, prepared a most elaborate review on the mosquitoes bred in the State of New Jersey, which, if not out of print, is obtainable by application to Dr. Lipman, Director of the State Experiment Station, New Brunswick, N. J. Dr. Ethan P. Felt, State Entomologist of New York, has prepared a review on the mosquitoes of New York State, which is intended for free distribution. There are numerous other books on the same subject, many of which are printed abroad.

The writer quotes herewith in full the "Mosquito Brief" prepared, a few years ago, by the American Mosquito Extermination Society, with the aid and endorsement of the members of the Advisory Board of Entomologists. This Brief may be regarded as the A-B-C of the whole problem of mosquito prevention, and is authoritative.

"MOSQUITO BRIEF.

"1.—There are over 100 species of Mosquitoes in the United States.

"2.—Mosquitoes breed only in water. They may breed in any kind of quiet water unstocked with destroying fish.

"3.—Mosquitoes generally require from one to three weeks to develop from eggs to winged insects in warm weather, longer in cold weather. Some female mosquitoes three days old lay eggs, the average is greater. Some species lay as many as three or four hundred eggs at once, some lay them singly. Mosquitoes may live several months (as shown by hibernation and otherwise), but probably few live over a month.

"4.—Mosquitoes do not breed in grass, but rank growths of weeds or grass may conceal small breeding puddles, and form a favorite harboring place for adults. The Pitcher Plant holds sufficient water to breed a rare and small species.

"5.—Different species of mosquitoes have as well defined habits as different kinds of birds, flies, etc. Some are Domestic, some Wild, some Migratory.

"6.—Most Domestic Mosquitoes breed in fresh water, fly short distances and habitually enter houses.

"7.—Most Migratory Mosquitoes breed in salt and brackish marsh areas, fly long distances. They are not conveyers of malaria.

"8.—Rigid tests, both direct and eliminative, have proved that certain species of mosquitoes are the only known natural means of transmitting malaria and yellow fever. Some other diseases are known to be conveyed by mosquitoes.

"9.—Of the domestic varieties, the dangerous malarial mosquitoes (several species of the genus Anopheles), are among the most generally distributed. They seem never to travel far, only a few hundred yards.

"10.—A most common and dangerous domestic mosquito in the South and the tropics is Stegomyia fasciata, which is the natural conveyer of yellow fever.

"11.—Mosquitoes are known to bite more than once, as can be seen by observation and is proved by the transmission of disease from an infected person to a new subject.

"12.—Mosquitoes are a needless and dangerous pest. Their propagation can be largely prevented by such methods as drainage or filling of wet areas, removal, emptying or screening of water receptacles, spraying standing water with oil where other remedies are impracticable. Attention should be paid to cisterns, house-vases, cesspools, road basins, sewers, watering troughs, roof gutters, old tin cans, holes in trees, marshes, swamps and puddles. As malarial mosquitoes may be bred in clear springs, the edges of such places should be kept clean, and they should be stocked with small fish. The breeding and protection of insectivorous birds such as swallows and martins, should be encouraged. Thorough screening of houses and cisterns is necessary to prevent the spread of malaria or yellow fever. The continued breeding of any kind of mosquitoes with the attendant menace to public health and to the life and comfort of man and beast is therefore the result of ignorance or neglect."

The writer's own observations, which cover the past eleven years, have seemed to establish the fact that the most troublesome varieties of mosquitoes are those bred in man-made water holders. Common house mosquitoes habitually enter houses and are busy all night singing and stinging. When these mosquitoes are ready to lay their eggs, they leave the house for the nearest spot where standing water is to be found. They lay their eggs in rain-water barrels (man-made water holders); in cesspools (made by man); in rain-water gutters which are not kept clean; in fire-pails; in pools formed in excavations, cellars, trenches, etc. These man-made water holders are prolific breeders chiefly because they breed nothing else. Natural pools which hold water for a greater part of the season frequently contain water beetles and other creatures which devour the mosquito larvæ, and thus prevent their development into winged insects.

Another fact established by the writer's observations is that it pays to eliminate breeding places throughout small areas, and that the greater the area thoroughly controlled the better will be the results. For example, he observed one section where no mosquitoes were seen for two weeks, while people living less than 400 ft. therefrom were suffering severely from the pest. An examination showed that where the mosquitoes were troublesome, two water barrels were found breeding extensively.

Another example which came under his observation, was that of a municipality, 2 miles square, which was known to be thoroughly controlled, but was found to suffer considerably from common house mosquitoes which were breeding extensively beyond its borders.

Because of these experiences, he believes that the unit of operation against mosquito breeding should be enlarged. The county becomes a proper sized unit; furthermore, all counties throughout a State should work in unison in order to accomplish the best results. A law passed by the State Legislature of New Jersey during the session of 1912 is printed herewith. It provides for the appointment of commissioners by the Supreme Court Judge of each county throughout the State. It also provides for raising, by taxation, the funds needed to carry on the work of mosquito prevention.

"CHAPTER 104.

"An Act for the establishment of county mosquito extermination commissions and to define their powers and duties.

"BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

"1. In any county of this State it shall be the duty of the justice of the Supreme Court presiding over the courts of said county to appoint six persons, three of whom must be persons who are or have been members or employes of boards of health. A board of commissioners to be known as 'The County Mosquito Extermination Commission,' inserting the name of the county in and for which the commissioners are appointed. The commissioners first appointed under the provisions of this act in any county shall hold office respectively for the term of one, two, and three years, as indicated and fixed in the order of appointment, and all such commissioners, after the first appointment, shall be so appointed for the full term of three years; vacancies in the said commission occurring by resignation or otherwise shall be filled by such justice, and the persons appointed to fill such vacancies shall be appointed for the unexpired term only; such persons so appointed, when duly qualified, constituting such commission and their successors are hereby created a body politic, with

Judge of Supreme Court to appoint commission.

Official name.

Terms.

Vacancies.

power to sue and be sued, to use a common seal and make by-laws; Expenses paid. the members of any such commission shall serve without compensation, except that the necessary expenses of each commissioner for actual attendance on meetings of said commission shall be allowed and paid. Oath. No persons employed by the said commission shall be a member thereof; before entering upon the duties of his office each commissioner shall take and subscribe an oath or affirmation before the clerk of the county in and for which he is appointed to faithfully and impartially perform the duties of his office, which oath or affirmation shall be filed with the clerk of the county wherein the commission Organization. of which he is a member is appointed; every such commission shall annually choose from among its members a president and treasurer, and appoint a clerk or secretary and such other officers and employes as it may deem necessary to carry out the purposes of this act; it may also determine the duties and compensation of such employes, Office. and make all rules and regulations respecting the same. It shall be the duty of the board of chosen freeholders in each county to provide such commission with a suitable office where its maps, plans, documents, records, and accounts shall be kept, subject to public inspection at such times and under such reasonable regulations as the commission may determine.

Duty of director of experiment station. "2. The director of the State Experiment Station shall be a member ex officio of each commission and shall co-operate with them for the effective carrying out of their plans and work. The said director shall serve without compensation, except that the necessary expenses actually incurred by him in the attendance on meetings of said commissions shall be allowed and paid. He shall furnish the said commissions with such surveys, maps, information, and advice as they may require for the prosecution of their work, or, as in his opinion, will be of advantage in connection therewith.

Powers. "3. Every such commission shall have the power to eliminate all breeding places of mosquitoes within the county wherein it is appointed, and to do and perform all acts and to carry out all plans which in their opinion and judgment may be necessary or proper for the elimination of breeding places of mosquitoes, or which will tend to exterminate mosquitoes within said county.

Annual estimate. "4. Said commission shall, on or before the first day of April in each and every year, file with the director of the State Experiment Station a detailed estimate of the moneys required for the ensuing year, and a plan of the work to be done and the methods to be employed. The said director shall have the power to approve, modify or alter the said estimates, plans and methods, and the estimate, plan and method finally approved by him shall be by him forwarded to the board of chosen freeholders in each county on or before the first day of May following its receipt.

"5. It shall be the duty of the board of chosen freeholders of each county, or other body having control of the finances thereof, to include the amount of money approved by the director of the State Experiment Station, annually in the tax levy; *provided, however,* that in no year shall the amount so raised exceed the amount hereinafter specified, to wit, in counties where the assessed valuations are not more than twenty-five million dollars, a sum not greater than one mill on every dollar of assessed valuations; in counties where the assessed valuations are not more than fifty million dollars a sum not more than one-half of one mill on every dollar of assessed valuations; in counties in which the assessed valuations are in excess of fifty million dollars a sum not more than one-quarter of one mill on every dollar of assessed valuations.

Appropriation.

Proviso; amount raised annually.

"6. The moneys so raised, or so much thereof as may be required, shall be paid from time to time to the said mosquito commission on the requisition of said commission, duly signed and approved by the president and secretary thereof.

Payments.

"7. It shall be the duty of each commission annually, on or before the first day of November in each year, to submit to the director of the State Experiment Station and to the board of chosen freeholders in their respective counties a report setting forth the amount of moneys expended during the previous year, the methods employed, the work accomplished and any other information which in their judgment may seem pertinent.

Annual report.

"8. Nothing in this act shall be construed to alter, amend, modify or repeal the provisions of chapter 134 of the laws of 1906, or alter, amend, modify or repeal any act now existing conferring upon State or local boards of health any powers or duties in connection with the extermination of mosquitoes in said State, but shall be construed to be supplementary thereto.

Act considered supplementary.

"9. This act shall take effect immediately.

"Approved March 21, 1912."

The Essex County, New Jersey, Mosquito Extermination Commission was organized in March, 1912, and under this law obtained $75 000 from the Board of County Freeholders to carry out the work in the county during 12 months ending May 1st, 1913. There are about 600 000 people in Essex County, and this tax amounts to 12½ cents per inhabitant per annum. The work accomplished during 1912 has been extraordinary; on every side the same story is heard: "We have never known a year when we have seen so few mosquitoes. We might almost say we have hardly seen one in our house this year."

The organization of this Commission is as follows:

1.—Six Commissioners serving without salary.
2.—One Chief Inspector, salary, $1 800 per annum.
3.—One Secretary, salary, $1 200 per annum.
4.—One Assistant Chief Inspector, $1 500 per annum.
5.—Three Deputy Chief Inspectors (who must qualify as engineers), salary, $1 200 per annum.
6.—Forty-five Inspectors at $3 per day.
7.—Thirty to forty laborers at $2 per day.
8.—Stenographer and Clerk, salary, $600 per annum.

Each inspector patrols a distinct district, making his rounds once in every 10 days. In certain sections of the City of Newark, a day's work for an inspector is from 100 to 300 houses; a day's work for an inspector in the outlying districts is far less. All breeding places which cannot be eliminated at once are recorded on maps made by the Deputy Chief Inspectors.

In closing, the writer wishes to emphasize:

1.—That all standing water does not breed mosquitoes, and great economy can be effected in the cost of drainage and oiling if each pool of standing water is carefully examined for mosquito larvæ before any work is expended thereon.

2.—That we will never be relieved of the work of mosquito prevention. The fight will be continuous, and any slackening of vigilance on the part of the organization will invite the immediate reappearance of the pest.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

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THE SANITATION OF CONSTRUCTION CAMPS.

By Harold Farnsworth Gray, Jun. Am. Soc. C. E.

To be Presented December 18th, 1912.

A problem which often confronts the engineer or contractor engaged in work which requires the establishment of a camp, is the keeping of labor steadily on the job in such physical and mental condition that each man puts forth his best efforts. This is especially true when work is prosecuted in new and unpopulated country, where life at its best must be rough and at times hard. The engineer in charge may have to carry on the work with a labor force depleted by sickness. As a result, many may leave permanently, and many of those who remain may be in such poor health that their physical efficiency is greatly impaired. A shifting or half-sick labor force cannot be efficient.

The writer has seen camps where a considerable proportion of the men were laid off because of intestinal disorders, due largely to poor sanitation, and where the efficiency of the force was reduced perhaps one-half. He has been in camps in malarial regions where the reduction in efficiency of the force was known to be at least one-quarter, and at times was probably greater. Such conditions represent a serious loss to the contractor, a loss which can be almost entirely eliminated by the observance of a few simple rules

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

based on the present knowledge of disease prevention. In the following the writer proposes to set forth briefly some of the principles of sanitation which are applicable to camp conditions, in the hope that he may convince the Engineering Profession that good camp sanitation is an economy, and not an expense.

Camp Location.—The matters of site and soil conditions are not of prime importance. Even under the poorest natural conditions, good health may be maintained in the camp if the proper sanitary measures are taken, but the better the natural conditions, the fewer and less costly will be the sanitary measures required.

Preference should be given to an even surface with a slight natural slope. An even surface promotes convenience and accessibility, and a slight slope gives a quick run-off for possible rain water. In cool climates a sunny exposure should be selected, and, in hot climates, the shady side of a valley, if possible. Low places, swamps, and wet areas should be avoided, as these may be breeding places of malaria-bearing mosquitoes. A light, porous soil is an advantage, not that disease lurks in the emanations from damp ground, but because of the added comfort of dry quarters.

Housing.—The form of housing will depend largely on the duration of operations and on transportation facilities. Whether tents, portable houses, or the more permanent wooden bunk-houses are used, ample provision for the free entrance of air and sunlight should be made. If wooden bunk-houses are used, the window space should be ample, and the windows swung inward on hinges at the side of the frames. In warm climates, in summer, and especially in fly and mosquito regions, the doors and windows should be screened, as described later.

One or more able-bodied men, as required, should be assigned to janitor duty. Each day all quarters should be opened as widely as possible for several hours during the morning for ventilation, and thoroughly cleaned by the janitor. Dirty conditions and violations of the camp rules should be reported by him, and the offender warned, disciplined, or discharged, according to the magnitude and frequency of the offense. With proper cleanliness, disinfectants are not required, except in unusual circumstances.

In cold climates, and during the winter, stoves (of a type which carries the products of combustion out of the room) should be provided, and fuel supplied to the men.

Mess-House.—The mess-house and kitchen should be especially well ventilated, but all doors, windows, and other openings should be screened with a copper or bronze wire of No. 18 mesh screen. Doors should be provided with springs to keep them closed. In order to prevent the entrance of insects around the edges of screens, the frames should close flush against wood strips nailed to the casing.

All reasonable means for obtaining cleanliness in the preparation and handling of food should be provided, and the kitchen and mess-house should be thoroughly cleaned after each meal. It is desirable that the various sources of food supply be known, where possible, and only such foods accepted as are wholesome and are produced and marketed under reasonably clean conditions. This is no doubt difficult under average conditions, but is worth considerable effort. As far as possible, the diet should be suitable to the season. No person afflicted with a communicable disease should be allowed to work in any capacity in the kitchen or mess-house.

Garbage.—Metal receptacles, provided with tight metal covers, should be supplied and used for the kitchen wastes, both solid (garbage) and liquid (slops). In camps which are to be maintained for a period of two weeks or longer, all garbage and slops should be destroyed by incineration, as any other form of disposal will probably permit fly-breeding. In no case should either garbage or slops be emptied on the ground, even at a considerable distance from the camp. Fig. 1 shows a simple and inexpensive garbage and slops incinerator, designed by Maj. Paul F. Straub, G. S., U. S. Army, and is given here by his permission. This incinerator was used successfully at the maneuver camp at San Antonio, Tex., in 1911. With proper attention it will destroy 100 gal. of slops and 23 cu. ft. of garbage in 12 hours, with a fuel consumption of $\frac{1}{16}$ cord of wood. With the ordinary attention which would be given in a construction camp, lacking in rigid military discipline, the fuel consumption would be greater, but $\frac{1}{6}$ cord per day should be ample for the destruction of all garbage and slops created in the preparation of food for 100 men.

The liquid slops are evaporated by being poured slowly along the walls of the incinerator, and the garbage is placed on top of the fuel. If rock for the construction of the incinerator is not available, a trench of the same form and capacity may be dug in the ground, and operated in the same manner. Great care should be taken to see that the garbage is thoroughly consumed; otherwise, fly-breeding may ensue if the incinerator is not used constantly.

Latrines.—Indiscriminate defecation and urination in the vicinity of the camp should be prohibited, and a sufficient number of latrines constructed at convenient places. A two-hole seat with a urinal trough is a good standard for the average camp, and the latrines should be placed so that the maximum distance from any house or tent to the nearest latrine does not exceed 100 ft. With easy accessibility of latrines, promiscuous defecation is more easily discouraged.

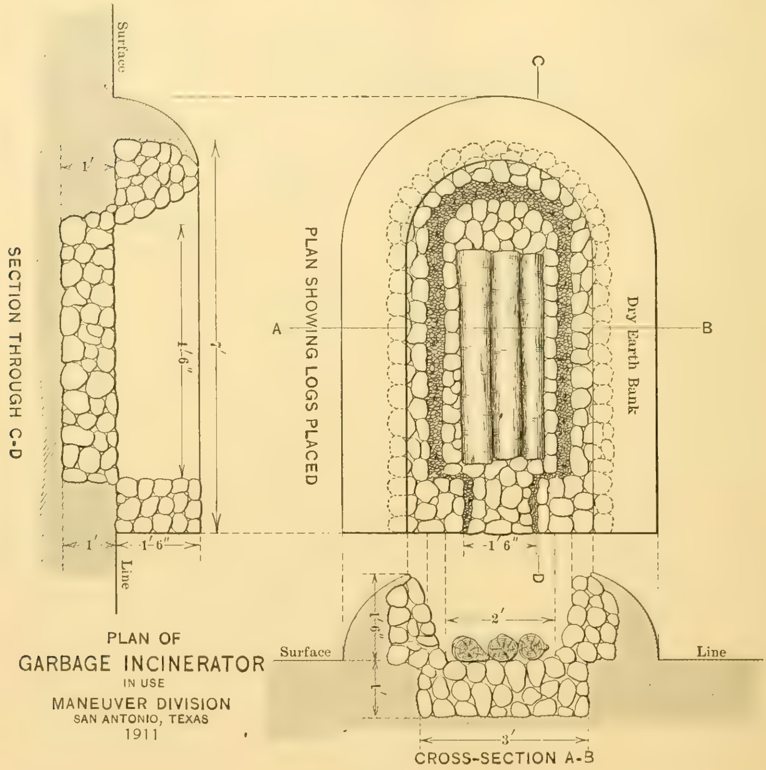
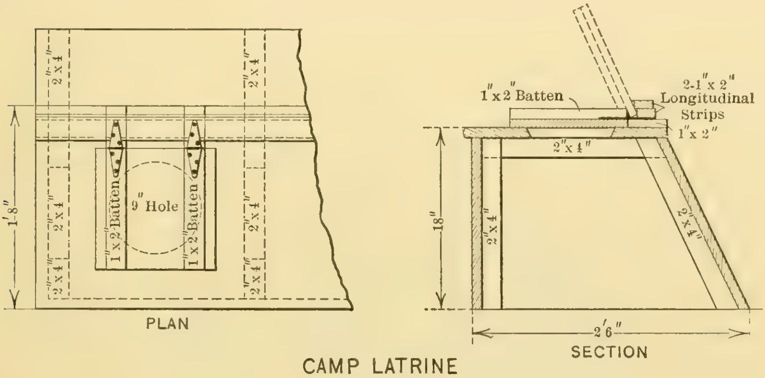


FIG. 1.

The latrines consist of three parts: the pit, the box, and the shelter. The pit should be 6 ft. or more in depth, and in section slightly smaller than the box. The box is shown by Fig. 2 (also by permission of Maj. Straub). It should be made of tongued-and-grooved boards, as ordinary lumber tends to warp and shrink, so that it is difficult to keep the box fly-tight, reliance being placed on the tightness of the box to prevent the access of flies to the contents of the latrine. The covers of the holes should drop back automatically into place over the holes when the seat is not occupied. In summer no roof is provided for the shelter which, for privacy, is built around the latrine, as the direct action of sunlight and air is desirable as a disinfectant and deodorant. During the winter a roof may be provided, and during rains, at other seasons of the year, a tarpaulin should be used.



CAMP LATRINE

Fig. 2.

A metal urinal trough may be attached to the side of the latrine shelter, discharging into the pit through the box *via* a trap. The pit should be disinfected daily by being burned out with oil or oil-soaked straw. The urinal trough should be flushed with water and limed, and the interior of the box and the pit should be limed after being burned, to deodorize the latrine. Cleanliness in the use of latrines must be strongly insisted on, especially if the laborers are of foreign nationality.

Stables.—The stable, especially the stalls, should be cleaned out thoroughly each day, and the manure removed to a point at least ½ mile from the camp and burned with oil. In a hot, dry climate, it will suffice to remove the manure to this distance and spread it out thinly on the ground; either method will prevent fly-breeding.

Under average conditions, horse manures are the favorite breeding places of flies. From estimates based on actual counts of representative samples, it has been shown that a manure pile weighing 1 000 lb. may contain upward of 450 000 fly maggots at the end of 4 days' exposure. Therefore, unusual care should be taken of manures, and the stables kept clean. There is no substitute for cleanliness; treating the stalls and manure with oils, chemicals, and poisons is in general more expensive and less effective than cleanliness and the proper disposal of manure.

Water Supply.—An endeavor should be made to obtain a pure water supply. Where the water is known to be polluted, it can be sterilized by calcium hypochlorite (chloride of lime or bleaching powder), used at the rate of from 10 to 40 lb. per million gallons, depending on the intensity of pollution. When used in this amount no taste or odor of the chemical will be noticed, and the water will be potable and practically sterile. For more permanent camps with polluted water supplies, sand filters can be constructed cheaply of wood, and can be made to give a fairly good effluent. Wells should be protected from surface contamination, and should not be placed in the vicinity of latrines.

Where camps are located on the water-shed of a city water supply, it will be necessary to take precautions to prevent the pollution of the supply by the camp. All such necessary precautions are usually covered by the laws of the State in which the camp is located.

Baths and Laundry.—In many respects personal cleanliness is one of the most important factors in health preservation, for the reason that disease is largely transmitted by contact, from person to person. It is advisable, therefore, that facilities for keeping personally clean be provided, and the men encouraged to make use of them. Shower baths can be easily and cheaply constructed. A simple and effective shower can be made from a 2-ft. length of 1-in. pipe, capped; along the lower side of the pipe are bored three parallel rows of $\frac{1}{16}$-in. holes set $\frac{3}{8}$ in. apart. The pipe projects horizontally from a tee in the vertical supply pipe, at about 8 ft. above the floor. The latter should be of wood with open joints. The bath should be provided with a shelter, and be without a roof in summer.

Laundry equipment and supplies, such as tubs, washboards, and soap, should be furnished gratis.

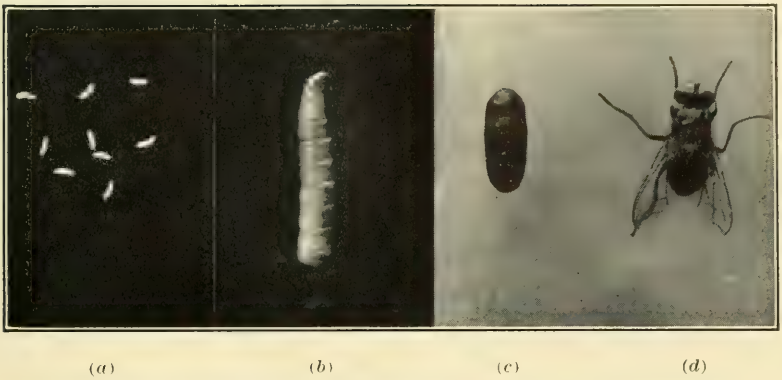


Fig. 1.—Development of the Common House Fly.
(*a*) Eggs. (*b*) Larva or Maggot. (*c*) Pupa. (*d*) Adult Fly.

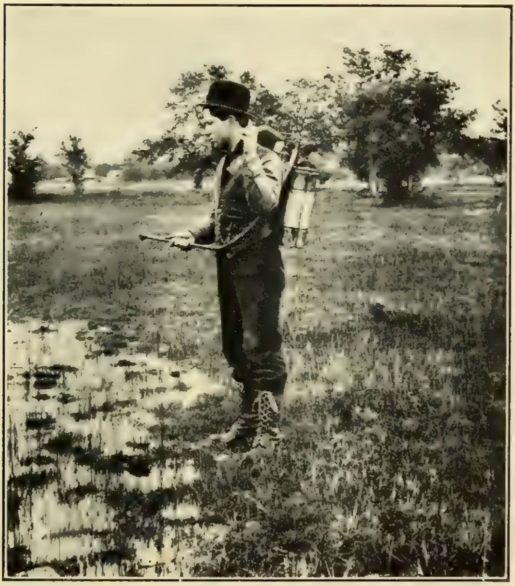


Fig. 2.—Knapsack Spray-Pump in Use, Spraying Oil on a Typical Anopheline Breeding Place.

Rubbish.—Unless cared for, considerable rubbish tends to accumulate in any camp. It should be collected daily by the janitor, removed to a specified place, and burned. Everything which tends toward neatness and cleanliness should be encouraged.

Flies.—The principal breeding places of flies, namely, manure piles, garbage heaps, and latrine pits, have been mentioned. They may also breed in any collection of decomposing organic matter, no matter how small. The fundamental theorem of fly control is cleanliness combined with proper destruction of waste products. Where destruction is not feasible, the rendering of such wastes unsuitable to fly-breeding, or inaccessible to flies, may be substituted.

Under midsummer conditions, flies will develop from egg to adult in from 10 to 14 days. The adult female lays from 75 to 125 eggs on the surface of the breeding material, and there may be several such layings during the average life of the insect. The eggs hatch in from 12 to 24 hours; the larvæ or maggots feed from 4 to 7 days, crawl away to the lower part of the breeding material, or into the adjacent earth, and pupate; in the pupal stage they remain quiet 4 days or more, and emerge full-grown flies. Fig. 1, Plate CXXX, given by courtesy of William B. Herms, Assistant Professor of Applied Parasitology, University of California, shows the four stages in the development of the common house-fly.

The rapidity of development is dependent on temperature, being accelerated by warmth and retarded by cold. Owing to the fairly constant warmth of decaying organic matter (for example, manure), the larval period is very nearly constant. The pupal period, being spent away from the decaying material, shows the greatest variation, and, in winter, may be lengthened to several months.

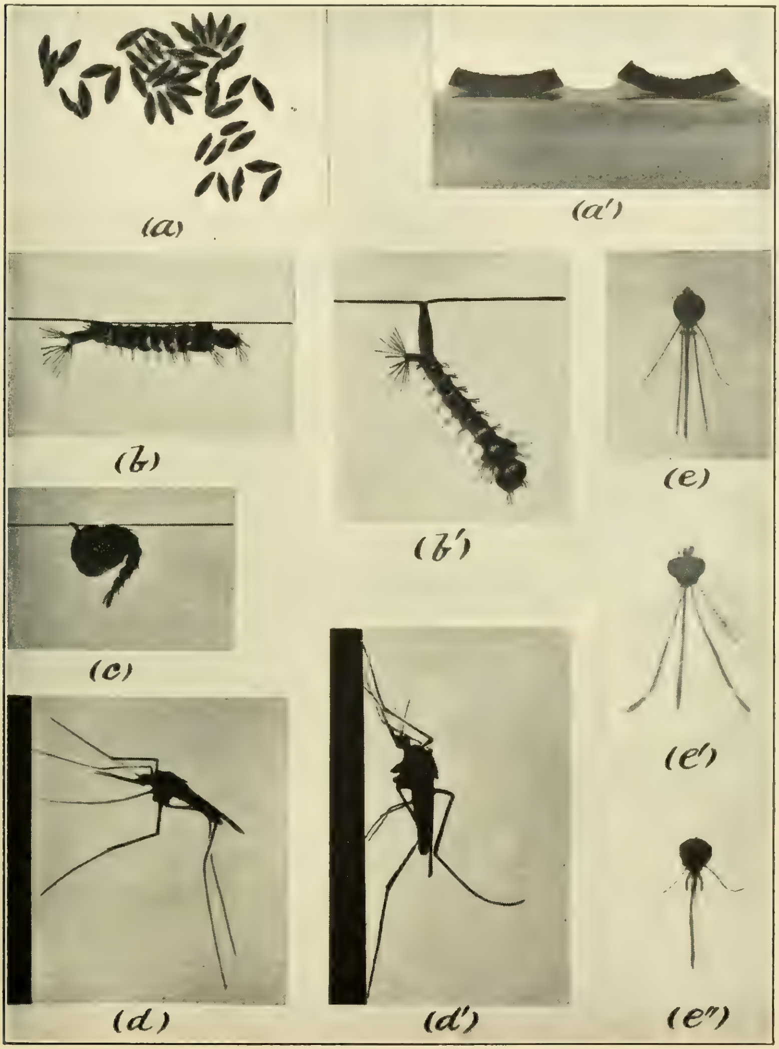
Owing to the fact that the fly maggot is very resistant to poisons and insecticides, it will be found cheaper and more effective, as previously stated, to destroy or remove the breeding material, than attempt to treat accumulations with poisons.

It has been proven conclusively that under conditions such as are usual in camps, flies may be gross transmitters of such diseases as typhoid, dysentery, and various intestinal disorders. During the Spanish-American War, when more soldiers were killed by disease than by bullets, large numbers of flies were often observed on the food in the mess-tents, the bodies and feet of many of them being whitened by the lime in the latrines which they had recently visited.

It may be stated almost as an axiom that the sanitary condition of a camp varies inversely as the numbers of flies present.

Malaria and Mosquitoes.—It is now conclusively proven that mosquitoes of a certain type are the sole transmitters of malaria. This disease is most prevalent during the warm months of the year, when the largest amount of construction work is carried on. In malarial regions the lost efficiency of the labor force from this disease is often 25% and more. Even where malaria-bearing mosquitoes are not present, and those of the common type are numerous, it is advisable to take measures for their destruction, as a night disturbed by these insects does not put a man in the best condition for a hard day's work. As previously mentioned, the doors and windows of wood houses should be screened and, in mosquito districts, if tents are used, bed-nets supported by frames should be supplied.

The two types of mosquitoes, the *Anophelines,* or malaria transmitters, and the *Culicines,* or common mosquitoes, are shown in various stages of their life history on Plate CXXXI. The differences in the two types are easily recognized in three of the four stages. The *Culicines* lay their eggs on the water surface in boat-shaped masses of from 250 to 750 eggs; the *Anophelines* lay their eggs singly or in irregular clumps. In the larval or wriggler stage, passed in water, the *Culicines* project a posterior breathing tube to the surface, the remainder of the body hanging head downward at an angle with the surface; the *Anophelines* breathe while lying parallel to, and with every segment touching, the surface. The differences in the pupal or tumbler stage are not sufficiently well marked to be easily distinguished by the unaided eye. In the adult stage, two methods may be used to distinguish the types. The resting attitudes are different; an *Anopheline* resting on a plane surface holds the posterior part of the body away from the surface, the line of the body thus making a distinct angle of from 25 to 55° with the surface, whereas the *Culicine* adult rests with the line of the body parallel to the surface, or in a humpbacked position. The best method of distinction in the adult stage is based on the mouth parts, which can be seen with the unaided eye, but can be observed better with a low-power magnifying lens. In the *Anopheline* females, the palpi (the two appendages im-



Development of the Mosquito.

(*a*) Anopheline Eggs (After Howard). (*a'*) Culicine Egg-Boats.
(*b*) Anopheline Larva. (*b'*) Culicine Larva or Wriggler.
(*c*) Anopheline Pupa or Tumbler.
(*d*) Resting Attitude of Anopheline Adult.
(*d'*) Resting Attitude of Culicine Adult.
(*e*) Head and Appendages of Female Anopheline.
(*e'*) Head of Male Mosquito, Either Type.
(*e"*) Head and Appendages of Culicine Female.

mediately on each side of the central proboscis or beak) are approximately as long as the proboscis, while in the *Culicines* the palpi are shorter than half the length of the proboscis. The males, which do not suck blood, can be distinguished, if found, by the feathered or plumose antennæ or feelers.

Mosquitoes breed in stagnant or quiet water, the *Anophelines* preferring clear, fresh water standing but a few inches on grassy land. The *Culicines* are not as fastidious in their choice of breeding places, often thriving in the foulest water. The first principle of mosquito control, therefore, is the removal of all stagnant water. This may be effected by drainage, by filling in small low spots which cannot be readily drained, by emptying vessels which contain useless water, and by screening all others. Where drainage or filling in is not practicable, as will usually be the case in construction camps, oil or chemicals may be used to destroy the mosquito larvæ.

Oil sprayed on the surface of water which is breeding mosquitoes will kill them effectively by shutting off the air supply, the larvæ and pupæ dying by suffocation. The oil should have a specific gravity of about 30° Baumé, and may be applied conveniently and economically by a knapsack spray-pump, as shown in Fig. 2, Plate CXXX. Small ponds may be treated by throwing in several handfuls of cotton waste soaked in oil, which will gradually feed a film of oil on the surface for some time, and may be renewed at intervals.

Under midsummer conditions, the development of the mosquito requires from 10 to 14 days; in the spring and autumn, this period is somewhat longer. To prevent breeding, therefore, it is necessary to apply the oil by spraying once every 2 weeks in summer, and about once every 3 weeks in the spring and fall.

Where the water is full of vegetation, it is advisable to treat it first with copper sulphate (1 to 50 000) and then with oil. A preliminary copper sulphate treatment will be found an advantage where poisons or larvacides are used. Several poisons, such as nicotine sulphate, phinotas oil, and emulsions of a modified crude carbolic acid, have been used for mosquito destruction with varying success, but on the scale of operations which would be usually attempted for the protection of a construction camp, oil will be found to be cheaper and more effective.

It will seldom be necessary to carry on anti-mosquito operations beyond a distance of 400 yd. from the camp, and not all the water in this territory will be found to be breeding mosquitoes. Only water which is actually breeding them need be treated.

Medical Treatment.—While the subject of medical treatment of the sick does not properly come under the provisions of camp sanitation, it is advisable to consider it briefly here, on account of its relation to the control of disease. The character of such treatment will depend on the size of the camp and the country in which the work is carried on. For small camps, in sparsely inhabited regions, a medicine chest of standard remedies, with bandages, liniment, and first aid to the injured materials, should be provided, to be administered gratis as needed. In malarial regions, in addition to screening and mosquito destruction, a daily prophylactic dose of quinine should be urged on the employees. Where small camps are within easy reach of a town, arrangements should be made with a physician to call at regular times, and as needed in emergencies, and, in addition, the medical and first aid equipment should be provided for minor complaints.

Where several camps are working a large number of men, directed from a central field office, it is advisable, and usually practicable, to install a field hospital with a resident physician, who, in addition to his hospital duties, makes periodic inspections of the camps. The expense of the hospital is usually provided for by nominal deductions from the pay of each employee, which entitles him to free medical attendance if sick or injured. This is often done on works of magnitude, an example with which the writer is familiar being the Los Angeles Aqueduct.

In any case, an employee suffering from any form of communicable disease should at once be laid off and isolated from the others, to prevent as far as possible the further spread of the disease.

The Value of Good Sanitation.—In its broadest sense, sanitation includes all methods and procedures necessary for the prevention of the spread of diseases. In its practical workings, it is limited to certain fields, which are not very well defined, owing to the interrelations of various factors in disease prevention. The procedure in disease prevention may be arranged roughly in three main divisions: First, the control of the source of infection, practically always a person sick with the disease; second, the control of the carrier or means of distribution of the disease from one person to another; and third, the protection of the well persons individually.

The first division falls largely in the domain of the physician, though the engineer, by installing works for the prompt removal and purification of the infected discharges of the patient, plays his part here. The control of the carrier of infection, such as food, water, sewage, insects, etc., comprises the field of sanitation as usually defined, and in this field the engineer, chemist, bacteriologist, entomologist, and others, play the chief part. Personal hygiene largely covers the third division. All three divisions are links in a chain which is no stronger than its weakest link. Under camp conditions, however, it is not practicable to take the measures which are essential in an urban community, and it is not possible to pay much attention to personal hygiene. The bulk of disease prevention, therefore, must fall in the second division.

There are few engineers who are not familiar with the usual conditions in camps. Foul-smelling, open latrines swarming with flies, dirty and poorly ventilated quarters for the men, vile food, filthy mess-tent, and swarms of flies on and in everything, are the average conditions. Such being the case, it is well-nigh impossible for any man to remain in good physical condition, and it is the laborer's physical condition which largely determines the amount and character of his output. If a part of the labor force is weakened by ill-health, just that much less than the maximum possible work can be obtained. The contractor expects the maximum for his greatest profits; if he gets less than the maximum, he sustains a loss. A reduction of 25% in the efficiency of the labor force is not unusual. If we consider a camp of 100 men at an average daily wage of $2, this daily loss amounts to $50, and in a 30-day month would reach a total of $1 500. The additional cost of good sanitation above the amount spent for the poor sanitation which is at the bottom of this loss, would probably not exceed $250 per month, leaving a net profit, chargeable to good sanitation, of $1 250. The average saving would undoubtedly be less than this amount, but the writer does not believe that he has based this estimate on an extreme case. However, be the saving much or little, good sanitation in a camp is emphatically an economy, not an expense. Aside from ignorance, perhaps the chief reason that camp conditions are usually so bad is that the contractor can actually see in dollars and cents the money expended for good sanitation, while the saving cannot be expressed so accurately or in such tangible form. Nevertheless, the economy can be shown at least approximately in every case, and in extreme cases may represent the difference between a profit and a loss on the contract.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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STREET SPRINKLING IN ST. PAUL, MINN.

Discussion.*

By A. H. Blanchard, M. Am. Soc. C. E.

A. H. Blanchard, M. Am. Soc. C. E.—This paper brings to the attention of municipal engineers the value of cost data and accurate records of construction details. The speaker, however, only refers to this feature of the paper in order to express his appreciation of the author's services in bringing before the Society a comprehensive plan covering cost data and records in a field in which very little work of this character has been done. Mr. Blanchard.

A paper on the broad problems of the economics of street watering seems to be opportune. Up to this time there has been comparatively little discussion relative to the efficiency of street watering. In considering the problem from this standpoint, a question which occurs to any one interested in the subject is: What are the fundamental reasons for sprinkling streets with water? There are engineers who claim that the reason is mainly to lay the dust. Street sprinkling, as done by these engineers, is used for that purpose not only on macadam roads, but on pavements of all types. If pavements are properly cleaned (by methods which are adaptable in practically all American cities), is there any necessity to sprinkle them to lay the dust? The answer is in the negative, because, with a proper system of street cleaning, dust should not exist in such quantities as to require any process of dust laying. The question of laying dust on macadam roads naturally brings up for consideration the relative economics by watering and by other methods which have come into use within the past decade. This feature will not be considered by the speaker, as it has formed the subject of many discussions before this Society.†

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* Continued from October, 1912, *Proceedings*.

† *Transactions*, Am. Soc. C. E., Vol. LXV, pages 462 to 466, and Vol. LXXIII, pages 33 to 43.

Mr. Blanchard.

Another reason advanced by some municipal engineers is that street watering materially cools the atmosphere. These engineers, however, use street sprinkling methods from the middle of April to the middle of October. It is doubtful if, in the majority of cities, engineers could state conscientiously that it is necessary to cool the atmosphere during two-thirds of the time when streets are watered. It would be of material value if a series of experiments should be undertaken to determine how much the atmosphere is cooled within a certain reasonable distance above the pavement and on adjoining property by street sprinkling with water. G. A. Soper, M. Am. Soc. C. E., who has spent considerable time in investigating the subject, is particularly positive in the statement that no cooling effect is appreciable. Although it is admitted by many that it may not be appreciable from the standpoint of the actual temperature, it is believed, however, that on macadam roads, under certain local conditions, there is a cooling effect—at least mentally. One excellent example of this effect is seen in the method used in Monte Carlo. Although the macadam roads of the Principality of Monaco are rendered dustless in the main by the use of bituminous materials, in the instance of the light-colored limestone macadam roads in the vicinity of the Casino, surrounding the beautiful gardens laid out in front of that magnificent yellow limestone building, the streets are watered not only to give the effect of coolness, but also, from the esthetic standpoint, in order that the limestone macadam thus treated will harmonize with the beautiful buildings and residences which border these boulevards.

A third reason which has been advanced by some engineers is that street watering serves to clean the streets. The speaker does not believe that it is a question for consideration whether street sprinkling properly conducted does or does not clean the streets. Certainly, it is usually impracticable to clean macadam roads by watering without the creation of mud or the disintegration of the surface. With the figures at hand, it certainly is not economical to clean pavements by street sprinkling when they are used under conditions for which they are suitable and economical.

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A WESTERN TYPE OF MOVABLE WEIR DAM.

Discussion.*

By Thomas C. Atwood, M. Am. Soc. C. E.

Mr. Atwood.

Thomas C. Atwood, M. Am. Soc. C. E.—The author has performed a distinct service by bringing before the Society the subject of inexpensive movable dams for use in irrigation canals, small streams, etc., and in pointing out correct principles of design.

As he well states, "Their construction has largely been a growth of local or individual custom and experience, rather than of engineering design, and in many cases this is painfully apparent." It is to be hoped that the recent agitation for a stricter supervision of dams, following the failure of that at Austin, Pa., may extend even to such small structures as these, and that all of them may be placed in the hands of competent engineers.

This type of dam seems to be better adapted to irrigation canals than to streams, due to the likelihood of driftwood in the latter lodging against the bents in time of flood and holding back the water, in spite of the removal of the flash-boards, and, perhaps, causing the loss of the structure. For such locations, especially where the dam is a high one, as the diverting dam of the San Joaquin and Kings River Canal and Irrigation Company across the San Joaquin River, where the height is given as 16 ft., a type of movable dam which gives a clear waterway when lowered is usually to be preferred. Many such dams have been built by the United States Army Engineers, and have proved very successful. Although permanent in character, the cost of the waterway is not excessive, the principal expense being in the provision for navigation. The cost of the navigable pass of

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*This discussion (of the paper by W. C. Hammatt, M. Am. Soc. C. E., published in May, 1912, *Proceedings*, and presented at the meeting of September 18th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Atwood. Dam No. 26, on the Ohio River, is given by the U. S. Engineers' office as about $175 per ft., the dam being built on a rock foundation, and for a maximum head of 14.2 ft. Mr. J. W. Arras, U. S. Assistant Engineer, gives the probable cost of a Chanoine dam on piles in a gravel foundation as from $250 to $300 per ft. for a structure about 16 ft. in height, according to local conditions.

The failure of Dam No. 26 was due apparently to the failure of the rock foundation, although the unwatering of the site may reveal some other cause. This is worthy of note, in view of the almost uniform success of these dams when founded on the river gravel.

The author does well to lay stress on the importance of the foundation, and his suggested design, as shown in Fig. 5, is excellent in this respect on most points.

The subject of scour does not seem to be adequately treated, however, although Mr. Hammatt called attention to this point in his discussion* on the Yuma River Débris Barrier, where he suggested an unattached apron of large concrete blocks which would follow the bottom down, as scour takes place below the dam, and prevent the gravel under the dam itself from being washed away. This method is excellent, and has been used successfully, as have a number of others, as described by the writer in discussing the paper on the Yuma River Débris Barrier mentioned above.

The suggested design, as given in Fig. 5, is weak in this respect, as scour may reasonably be expected when the flash-boards are raised and the direct current strikes the small bulkhead, *H*, and jumps over it. This can be helped by moving this bulkhead nearer to the main dam, extending the plank apron farther down stream, or placing rip-rap below the apron to prevent scour and follow the bottom down if any occurs.

The best method, however, and probably the cheapest, is to slope the apron upward in the direction of the flow, with perhaps 2 ft. rise in 20 ft., giving the same depth of water just below the dam, but doing away with the bulkhead, *H*. There will still be scour, but it will be transferred to such a distance below the dam that the foundation of the structure will not be endangered, the tendency of the eddy being to bring gravel back toward the apron, rather than to scour that immediately adjacent.

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* *Transactions*, Am. Soc. C. E., Vol. LXXI, p. 229.

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PAPERS AND DISCUSSIONS

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THE SIXTH AVENUE SUBWAY OF THE HUDSON AND MANHATTAN RAILROAD.

Discussion.*

By Messrs. T. B. Whitney, Jr., William J. Boucher, Lazarus White, and H. L. Oestreich.

T. B. Whitney, Jr., M. Am. Soc. C. E. (by letter).—Judging from the author's statement that the weight of the reinforcing steel per cubic foot of concrete is excessive, it might be inferred that some abnormal percentage of steel was used in the design of the reinforced concrete in this structure. However, the steel ratio is not more than three-fourths of 1%, except in the side-walls which required reinforcing in both faces, where it amounts to 1.20 per cent. The longitudinal bars used to prevent shrinkage cracks averaged about fifteen-hundredths of 1 per cent. A minimum spacing of 6 in. from center to center was used for the steel in order to facilitate the pouring of the concrete. Mr. Whitney.

The arched roof formed a characteristic feature throughout the underground structures of the Hudson and Manhattan Railroad, and this led to its consideration in the design of the subway section on Sixth Avenue. The adopted section consists of a double, arched roof supported by a center wall and side-walls. The side-walls are designed as reinforced concrete slabs to carry the earth pressure as well as the thrust of the arches, and are tied together at top and bottom by tie-bars in the roof and floor.

A comparison of this subway section with two other well-known subway sections shows that the quantities of excavation, steel, and

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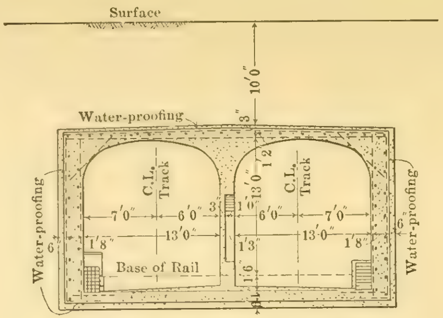
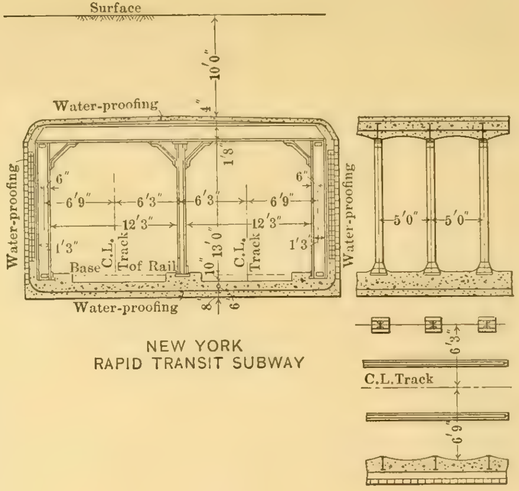
* This discussion (of the paper by H. G. Burrowes, M. Am. Soc. C. E., published in August, 1912, *Proceedings*, and presented at the meeting of October 2d, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

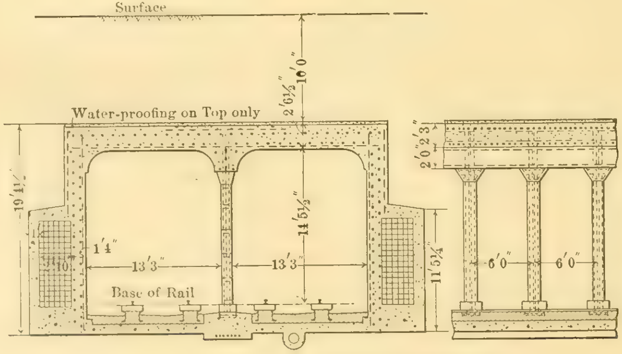
Mr. Whitney.



HUDSON & MANHATTAN R.R.CO.



NEW YORK
RAPID TRANSIT SUBWAY



MARKET ST.SUBWAY,PHILADELPHIA

QUANTITIES PER LINEAR FOOT OF TWO-TRACK SUBWAY									
	Inside Clearance	Outside Width over all	Excavation, in Cubic Yards	Concrete in Cubic Yards	Reinforcing Steel in Pounds	Structural Steel in Pounds	Total Steel in Pounds	Water-proofing in Square Yards	Concrete over Water proofing in Cubic Yards
Hudson & Manhattan	13′0″	31′7″	33.90	5.67	820	—	820	10.42	1.50
N.Y.R.T.Subway $f = 20\,000$ lb.	12′3″	29′10″	31.80	4.10	—	816	816	9.78	1.47
N.Y.R.T.Subway $f - 16,000$ lb.	12′3″	29′10″	31.80	4.10	—	991	991	9.78	1.47
Market St.Subway Philadelphia	13′3″	37′10″	43.70	7.80	574	206	780	3.50	0.29

FIG. 4.

Mr. Whitney.

concrete, are slightly in its favor, when the sections are reduced to the same dimensions, using the same loading and unit stresses in each case. The economic features may be compared by referring to Fig. 4. It will be noticed that the New York Subway has the smallest side clearance and that the steelwork is calculated on a basis of a unit stress of 20 000 lb., which accounts for the smaller quantities.

The permanent structure was designed to conform with the live and dead loads as given by the specifications of the New York Public Service Commission, though lower unit stresses were used than are prescribed by these specifications.

In each group of girders spanning the Pennsylvania Tunnel at 32d Street, the girder adjacent to the track carries half the trough track floor and train loads, in addition to its equal share of the permanent overhead loads, consisting of station platform, columns, roof, 20 ft. of fill, street railway, street loads, and elevated railroad structure. Economy of space was essential, so the over-all dimensions of all the girders were kept the same, and the additional flange area required for the girders carrying the track floor and train loads was provided by extra sets of angles placed inside the main flanges of the girder. The increase in web thickness, to provide proper rivet spacing, gave a surplus of material sufficient to carry the additional shear, as shown by Fig. 5. Thus, the extremely heavy overhead loads are carried by the main body of the girder, while the comparatively light track floor and train loads are carried by the inner sets of flange angles.

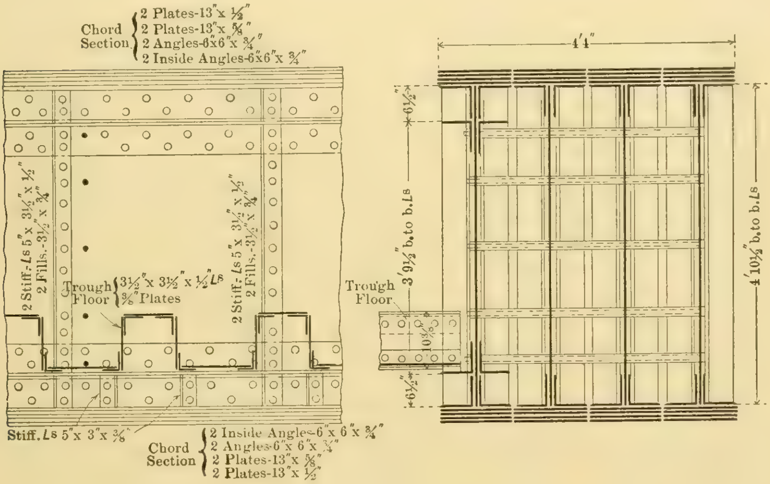


FIG. 5.

Mr. Whitney. The trough track floor rests on the outstanding leg of the inner flange angles, which is braced by stiffener angles, 12 in. from center to center, these angles transmitting the loads to the web of the girder. This arrangement simplifies the renewal of these floors.

Mr. Boucher. William J. Boucher, Assoc. M. Am. Soc. C. E.—While in Chicago and associated with the organization planning the proposed subway system for that city, about 2 years ago, the matter of water-proofing was quite thoroughly investigated by the speaker. Having been connected with the construction of the New York Rapid Transit Railroad, he was well acquainted with the membranous method of water-proofing, but the integral method of mixing a powdered or liquid substance with the concrete had not been examined to any extent.

At least six manufacturers of compounds offered, and had tests made of, their products, among which were McCormick, Medusa, Truss-Con, Hercules, Ceresit, and Hydrolithic. Due to various causes, the tests were not in every way satisfactory, but it was learned that laboratory tests were of little or no value. No subway has yet been built in Chicago, but the street railway tunnel under the Chicago River at La Salle Street has now been in use about a year. The reinforced concrete approaches to this tunnel, and the concrete-lined steel tubes forming the river crossing are water-proofed solely by mixing McCormick compound with the concrete. The speaker has been informed by a representative of the company handling that brand, that the tunnel and its approaches at present are as dry as could be desired, the only places where water ever entered being at terminations of a day's work. These cracks and openings were closed by drilling holes through the concrete and forcing grout composed of water-proofed cement back of and into the mass. The speaker is further informed that since the completion of the street railway tunnel under the Chicago River at Washington Street, which was constructed of plain concrete, it has been treated with a thin mortar or grout of water-proofed cement, at various leaky places (as well as in the pump-room of the tunnel, which is on the shore, but below river level), and the results have been very satisfactory.

It will be interesting to learn whether the result of using a compound with the cement in the Hudson and Manhattan Railroad, has been satisfactory; whether cracks occurred and caulking was necessary, and whether the extra cost of the compound was justified, rather than the use of a richer cement mixture and more care in placing the concrete.

The first subway built in New York was a steel-beam structure, walls and roof. The first experimental piece of reinforced concrete subway was built from the Rapid Transit Commissioner's plans on Lenox Avenue, northward from 141st Street, a cross-section of which is shown on Fig. 6. Then followed an era, covering about 6 years, in

Mr. Boucher.

CROSS-SECTION OF ORIGINAL REINFORCED CONCRETE SUBWAY
ON LINE OF RAPID TRANSIT RAILROAD, LENOX AVENUE AND 141ST ST., NEW YORK.

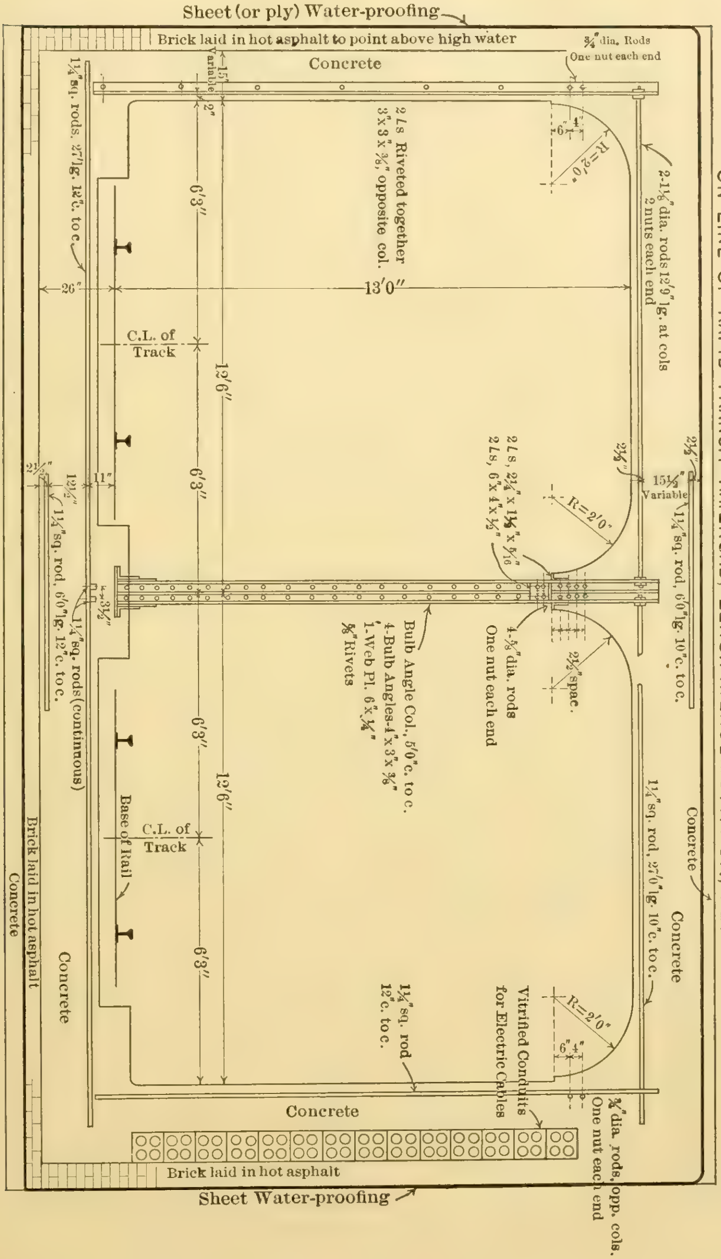

Sheet (or ply) Water-proofing
Brick laid in hot asphalt to point above high water
3/4" dia. Rods
One nut each end
Concrete
15"
Variable
2"
1 1/4" sq. rods. 27' lg. 12" c. to c.
2 Ls Riveted together
3" x 3" x 3/8", opposite col.
6"
4"
R=2'0"
2-1 1/8" dia. rods 12'9" lg. at cols
2 nuts each end
6'3"
26"
13'0"
C.L. of Track
12'6"
2 1/2"
15 1/2"
Variable
2 Ls, 2 1/4" x 1 1/8" x 5/16"
2 Ls, 6" x 4" x 1/2"
R=2'0"
1 1/4" sq. rod, 6'0" lg. 10" c. to c.
2 1/2"
12 1/2"
11"
6'3"
1 1/4" sq. rod, 6'0" lg. 12" c. to c.
3 1/2"
1 1/4" sq. rods (continuous)
Bulb Angle Col., 5'0" c. to c.
4-Bulb Angles-4" x 3" x 3/8"
1-Web Pl. 6" x 1/4"
5/8" Rivets
4-5/8" dia. rods
One nut each end
2 1/2" spac.
6'3"
12'6"
C.L. of Track
Base of Rail
Concrete
1 1/4" sq. rod, 27'0" lg. 10" c. to c.
Concrete
R=2'0"
6"
4"
Vitrified Conduits for Electric Cables
1 1/4" sq. rod
12" c. to c.
6'3"
Concrete
Brick laid in hot asphalt
Concrete
Concrete
Brick laid in hot asphalt
Sheet Water-proofing
3/4" dia. rods, opp. cols.
One nut each end

FIG. 6.

Mr. Boucher. which the subways were mainly of reinforced concrete, this construction being used under Battery Park, Manhattan, and Fulton Street, Flatbush Avenue, and Fourth Avenue to 40th Street, Brooklyn. The newer subways, however, are being designed and built as steel-beam structures, which seems to indicate that this type is preferable. Where surface cars and vehicle traffic, as well as elevated columns, must be supported, it seems to be far better to construct of beams, than rods, for then the loads may be transferred to the steelwork as soon as it is riveted, without waiting for the concrete to set. Can Mr. Burrowes state the reasons for adopting the reinforced type of construction for the Sixth Avenue subway?

Mr. White. LAZARUS WHITE, ASSOC. M. AM. SOC. C. E.—Would not Portland cement be a better compound than the material used on the subway work? In the work of the New York Board of Water Supply it was found that a little more Portland cement was better than any compound which could be added, no matter what its name—a mere name not producing dryness. If a wet concrete is used, and a liberal quantity of cement is carefully placed, that compound will be nearly water-proof; but nothing will make it water-proof at the joints. The advantage of the membrane method used on the subway is that it spans the joints and prevents water from getting through them.

Several tunnels were built for the Catskill Aqueduct, which, in the speaker's opinion, were dry enough to run subway trains through without any water-proofing other than the liberal use of Portland cement. These tunnels were deep, being several hundred feet below the ground, and after they were grouted off, successfully sustained very heavy ground-water pressures with very little leakage through the body of the concrete. A test* was made at the Wallkill Siphon, in which a stretch of tunnel was subjected to a head of several hundred feet of water. The arch had not been grouted, and leaked very slightly, but there was practically no leakage through the body of the concrete, showing conclusively that Portland cement is a sufficiently good water-proofing. The quantity of cement in this concrete, the speaker believes, was about 1.8 bbl. per cu. yd., corresponding to a 1:2:4 mix.

Mr. Oestreich. H. L. OESTREICH, M. AM. SOC. C. E.—The roof of the Fourth Avenue Subway, in Brooklyn, is of reinforced concrete, but no water-proofing was placed, a 6-in. layer of gravel on the roof acting as a drain to carry the water to the side of the tunnel. It was found that, if the structure leaked at all, it would be at the junction of two days' work. It is a question, therefore, whether Mr. Burrowes would not find the same conditions, even if he used the water-proofing powder in the concrete; in other words, while the slab placed one day might

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* *Engineering News*, December 14th, 1911.

Mr. Oestreich.

be water-proof, the line at which it joined the next day's work would show a leak. That was the experience on the Brooklyn Subway. It seemed almost as though the concrete formed a better bond with any other material than with itself.

In order to prevent leakage from the roof at the junction of two days' work, a furrow about 1 in. deep and 2 in. wide was cut into the concrete along this line and filled with tar. This helped the process of silting up, and the roof became practically dry.

On two contracts of the Fourth Avenue Subway the brick in mastic was omitted on the sides and bottom of the subway, a 6-in. layer of 1:2:4 reinforced concrete being substituted. The reinforcing consisted of ¾-in., longitudinal rods occupying four-tenths of 1% of the area of the concrete, the intention being to cause the shrinkage to be in many and small cracks rather than in one large one. Overlapping the rods 48 diameters tended to strengthen the junction of two days' work. Constant pumping for 2 years has reduced the elevation of the ground-water temporarily, but it is probably too early to speak definitely of results.

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A BRIEF DESCRIPTION OF A MODERN STREET RAILWAY TRACK CONSTRUCTION.

Discussion.[*]

By Messrs. E. E. R. Tratman, Walter C. Howe, and
Louis A. Mitchell.

Mr. Tratman.

E. E. R. Tratman, Assoc. M. Am. Soc. E. (by letter).—An interesting point suggested by this paper is the shape of the flangeway groove along the rail. It appears to be a rather wide, rectangular groove, having a flat bottom, vertical face, and sharp corner. It will be of interest to know whether this vertical face stands up under traffic, or whether the wheels of vehicles crush and crack it to an approximately beveled outline. The more usual method of forming the groove is to use nose-brick laid as headers with the top surface next the rail beveled so as to fit beneath the rail head. Still another plan is to use ordinary bricks (also laid as headers), tilted so that one end fits under the rail head while the top surface lies approximately in the contour of the crowning of the pavement between the rails. A third plan is to use a rectangular stretcher under the rail head (and projecting beyond it) and a higher bevel-edged stretcher level with the paving. In all these methods the groove or flangeway is of beveled or triangular section rather than rectangular.

In the Springfield work, the crowning of the paving between the rails, as shown in Fig. 1, appears to be unduly high, interfering with the normal cross-section of the street, and making an irregular contour. This is especially the case as the paving is $\frac{1}{2}$ in. below the rail head on the inside and $\frac{1}{4}$ in. below it on the outside, so that each rail forms a

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[*] This discussion (of the paper by A. C. Polk, Assoc. M. Am. Soc. C. E., published in August, 1912, *Proceedings* and presented at the meeting of October 16th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Tratman. distinct ridge in the pavement. This construction does not seem to be desirable in connection with a well-paved street surface, and it would be of interest to know whether the city authorities or the public have made any objection to it.

In regard to the wide spacing of the ties, experience has shown that the concrete immediately beneath the rail disintegrates or crushes, in some cases, due to the vibration and slight deflection of the rail, in spite of the fact that, theoretically, the rail has a continuous solid bearing.

Mr. Howe. WALTER C. HOWE, ASSOC. M. AM. SOC. C. E. (by letter).—This paper is both interesting and instructive. The writer has found very little published data on work of this class, although it is one of the most important features in the construction of modern pavements. Municipal engineers are often at a disadvantage in drawing up ordinances and specifications governing the control of paving in the excepted portion occupied by street railways.

The writer was Commissioner of Streets of Oakland, Cal., for a number of years, and observed that the initial point of failure of all asphalt streets was that portion immediately contiguous to the rails of the street railways, of both steam and electric roads. The asphalt surface adjoining the tracks was in a continual state of disrepair and disintegration. The failure of the pavement gradually extended outside of the railroad's portion and into that of the city. These conditions gradually became so serious that it was found necessary to adopt new and drastic ordinances governing the type of construction to be done by steam and traction lines occupying city streets. Few, if any, rails of modern type had been used by the companies previous to this action. A type of construction somewhat similar to that described by Mr. Polk was considered. The concrete extended to a depth of 6 in. under and completely across the length of the ties, but no steel reinforcement was used in the foundation. Strong opposition to this type of construction was made by the railway companies, and, as a compromise, rock ballast 6 in. deep was substituted for the 6 in. of concrete under the ties. There is no doubt that the class of construction shown by Mr. Polk is far superior, embodying, as it does, steel ties and a solid reinforced concrete foundation under them, thus affording extreme rigidity with a naturally decreased vibration. Its cost, however, is such as to preclude its use except in the case of street railway companies who are in excellent financial condition and whose officials are disposed and ready to meet with the municipality and adopt the most modern type of rail and foundation.

In many instances the official in charge of paving construction in a municipality is blamed for the dilapidated condition of paving, both adjoining and between the tracks of street railways, when, as a matter of fact, the entire trouble is due to the lack of co-operation

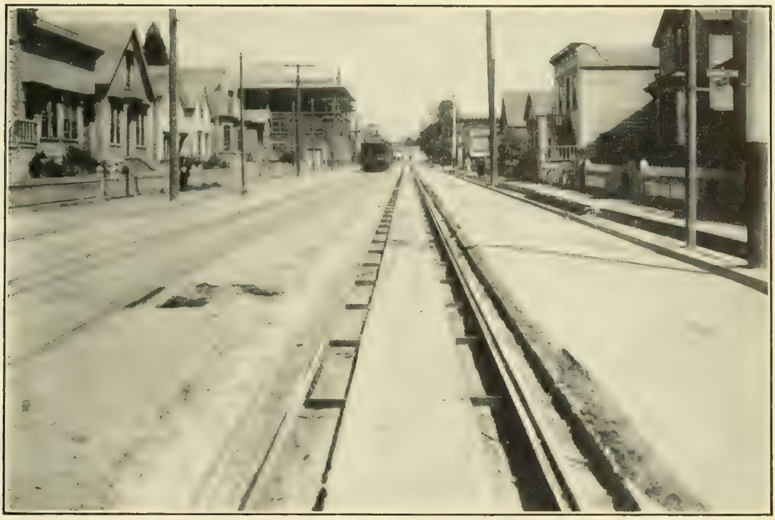

FIG. 1.—ASPHALT PAVING, TWENTY-SECOND STREET, OAKLAND, CAL. GIRDER-RAILS, STEEL TIE-PLATES, WOODEN TIES, CONCRETE TO BASE OF TIE, BASALT BLOCK LINERS ON 1½-IN. SAND CUSHION.

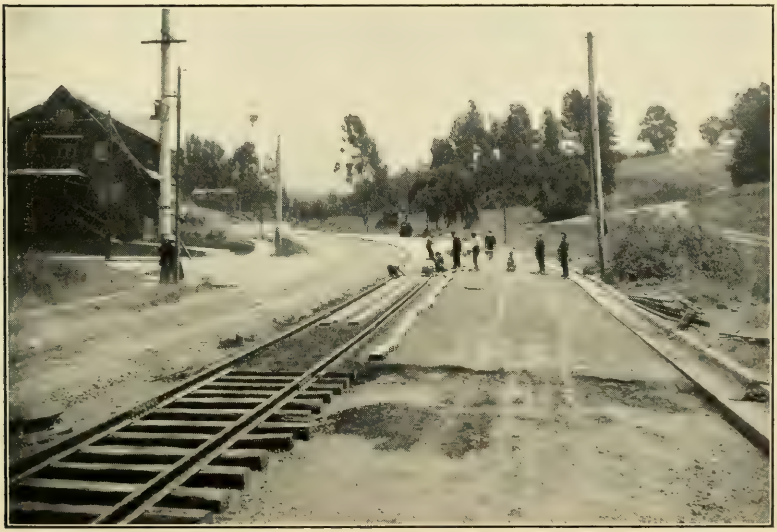

FIG. 2.—ASPHALT PAVING, FOURTH AVENUE, OAKLAND, CAL. VITRIFIED BRICK LINERS. ASPHALTIC CONCRETE BETWEEN TIES, INSTEAD OF HYDRAULIC CONCRETE.

on the part of the traction officials, or poor and worthless ordinances governing the control of the work, coupled with lack of support from the city fathers. Mr. Howe.

The writer makes no criticism of the construction described by Mr. Polk, but in the case of those who are about to go through the unenviable struggle of forcing public service corporations to use suitable construction to obviate ruined and dilapidated pavements adjoining railroad tracks, it may become necessary to follow an intermediate course, and in such case the construction described herein can be put down with good results. This type is not new by any means, but it embodies several unique features, such as a modern, 141-lb., 9-in. girder rail, with steel tie-plates and light concrete foundation; the substitution of asphaltic concrete for hydraulic concrete in some cases; the laying of paving blocks on their broad flat faces instead of on edge, etc., etc.

Previous to 1907, 90% of the asphalt and bituminous pavements contiguous to street railways in Oakland were in the condition shown in Fig. 1, Plate CXXXII. From time to time, efforts had been made by the traction lines to tooth the rails with basalt blocks in order to avoid this disintegration. No results were secured, as the asphalt surface broke up outside the line of the blocks. The condition was due simply to excessive vibration caused by the light T-rail used, coupled with lack of foundation and inferior roadbed. Under the existing State laws and the ordinances of the municipality, railway companies were required to pave their portion of the street, and for a distance 2 ft. outside of the outer rail, with the same class of pavement as that on the remainder of the street. Specifications governing new asphalt streets called for a concrete base of 6 in., a binder course 2 in. deep, and an asphalt wearing surface of 1½ in., making a total depth of 9½ in. for the completed pavement. Most of the rails laid throughout the city were the old type of light T-rail, ranging between 5 and 7 in. in depth. This gave approximately 2½ to 4½ in. of concrete below the top of the tie. The question as to whether the company could be compelled to increase the depth of the concrete between the ties and also line the rails with blocks, when the State laws required "that paving should be similar in all respects to the remainder of the street" was a legal one, the traction companies taking the stand that they were not required to do more than was called for by the State law. After many conferences and considerable discussion on the part of the city and traction officials, ordinances were drafted requiring the companies to line their tracks with types of paving brick or stone blocks satisfactory to the city, and to lay concrete the full depth of the ties. This type of construction was subjected to considerable criticism at the time. It was argued that the rigidity desired could not be secured unless the foundation concrete was carried to a depth of at least 6 in. under

Mr. Howe. the ties. The ordinance was adopted despite the criticism, and work was done on many miles of streets. The results have been uniformly satisfactory, notwithstanding the apparently cheap construction.

Fig. 2, Plate CXXXII, shows the west half of a completed asphalt street with basalt block liners toothing the rails. The concrete foundation on the right is complete and ready to receive the binder and surface materials. The open space adjoining the rails is ready to receive the block liners. The concrete was carried the full depth of the ties, practically encasing the wooden tie in a concrete body. Many of the ties showed signs of dry rot; the worst were removed, but many not badly affected were left in place. Owing to the depth of the rail, the basalt blocks were laid flat, instead of on edge, which considerably lessened the number used and naturally the cost. The blocks were laid on a sand cushion about 1 in. deep, and a 1:2 cement grout was swept into the joints. During the process of concreting, the traffic was carried on one track only, cross-overs being built at intermediate points. This allowed the concrete to set thoroughly before being subjected to the strain of traffic operations. This type of construction has proven very successful, although on a street carrying the cars of four branch lines controlled by the same company.

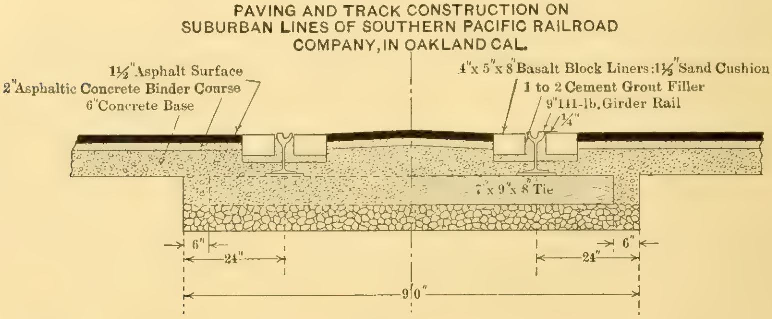
PAVING AND TRACK CONSTRUCTION ON
SUBURBAN LINES OF SOUTHERN PACIFIC RAILROAD
COMPANY, IN OAKLAND CAL.
1½" Asphalt Surface
2" Asphaltic Concrete Binder Course
6" Concrete Base
4"x 5"x 8" Basalt Block Liners: 1½" Sand Cushion
1 to 2 Cement Grout Filler
9" 141-lb. Girder Rail
¼"
7"x 9"x 8' Tie
6"
24"
6"
24"
9' 0"

FIG. 2.

Fig. 1, Plate CXXXIII, shows the completed asphalt pavement up to the line of the Key Route Company's tracks. On this street 141-lb. girder rails, 9 in. deep, were laid, with tie-plates as shown. The concrete extended only to the full depth of the tie. Spaces on both sides of the track are shown ready to receive the sand cushion and basalt blocks before laying the binder course and asphalt surfacing. Heavy interurban trains operate over this line.

Fig. 2 shows the type of construction on the Southern Pacific interurban lines. Girder rails of the same type were used, with basalt blocks set on edge. These blocks ranged in depth from 5 to 6 in.

Fig. 2, Plate CXXXIII, shows the type of construction used on Fourth Avenue, Oakland. Vitrified brick liners were used in place of basalt

PLATE CXXXIII.
PAPERS, AM. SOC. C. E.
NOVEMBER, 1912.
HOWE ON
STREET RAILWAY TRACK CONSTRUCTION

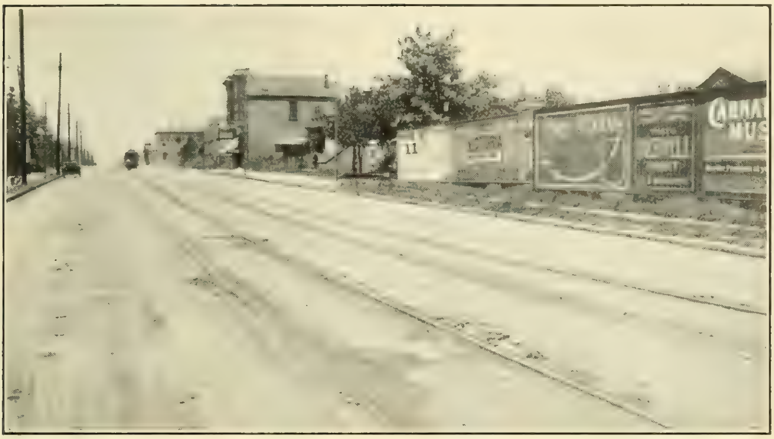

FIG. 1.—CONDITION OF ASPHALT PAVEMENTS ADJOINING CAR TRACKS WHERE NO LINERS ARE USED. OLD TYPE T-RAIL, AND LIGHT CONCRETE FOUNDATION BETWEEN TRACKS.

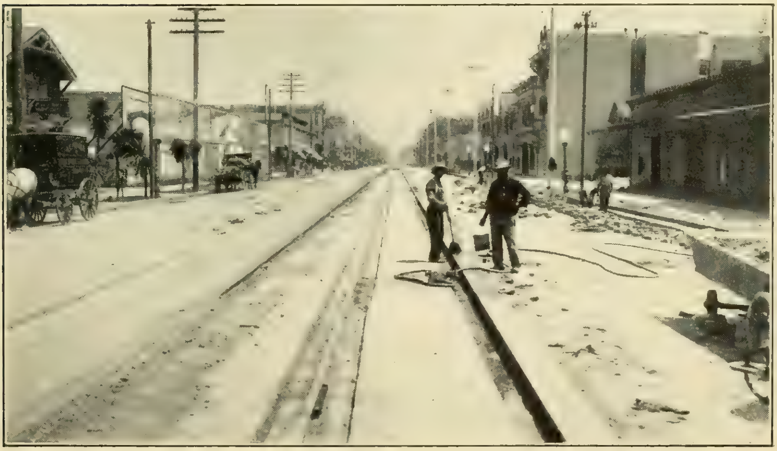

FIG. 2.—ASPHALT PAVING, BROADWAY, OAKLAND, CAL. BASALT BLOCK LINERS TOOTHING THE RAILS.

blocks, and the space between the ties and to their full depth was filled with a rich asphaltic concrete instead of hydraulic concrete. The old type of T-rail used is shown. As this line was single-tracked for a considerable distance, it became necessary to maintain traffic during the paving operations. For this reason, it was thought inadvisable to put in hydraulic concrete and operate the cars at the same time. To overcome this, asphaltic concrete was substituted and thoroughly tamped between the ties, being finally rolled with a 2½-ton tandem roller. This type of construction had been used on a number of other streets, but had not proved entirely successful. This work has been completed for several years, and when seen by the writer a few months ago was in very good condition, considering the type of rail used. Mr. Howe.

Asphalt oil bricks, similar to the Eastern type of asphalt blocks, were used as liners on several streets, but proved to be a failure. These bricks soon pounded into a uniform mass under turnout traffic from teaming, and thereby lost their individuality, taking on the general appearance of the asphalt surface adjoining. They proved to be inferior to the asphalt surface, as disintegration invariably occurred after the heavy rains, continuing during the heavy weather until the remaining portion of the block had to be removed. Asphalt blocks of better quality may obviate the earlier failures.

The construction described herein is not recommended for adoption wherever the more modern type can be secured. The best is none too good, as far as paving operations are concerned.

This type of construction has been universally adopted in Oakland, Cal., after a most successful experience covering a period of about 4 years.

Louis A. Mitchell, Assoc. M. Am. Soc. C. E. (by letter).—The writer has read this paper with much interest because similar problems are constantly coming up to be solved. Mr. Mitchell.

In the writer's experience, concrete beam construction, of which that described by Mr. Polk is a type, has not been very satisfactory for railroad tracks in paved streets. Its failure, however, has not been due necessarily to the type of construction nor to the area of the cross-section of the beam; though there is no doubt that some failures have been caused by the provision of insufficient bearing, and the fact that the loads have been too great. Most failures, however, have probably been due to loose joints which allow a slight movement of the rails when a wheel passes over them. This movement starts a hammer which the concrete will not stand, and, ultimately, the beam breaks under the joint.

By placing a steel tie directly under, and thus supporting, the joint, Mr. Polk has taken a step in advance in concrete beam construction, which, no doubt, will lengthen the life of the foundation. This sup-

Mr. Mitchell. port will prevent the working of the ends of the rails and the hammer on the concrete. The writer believes that the life of the joint will be greatly lengthened if the support under it is increased, at least, to the full length of the joint-bar, or longer. He has used steel ties constructed of 4-in. channels, 36 in. from center to center, and connected at the ends with $\frac{3}{16}$-in. steel plates. The rails rested on these steel plates, and the joint was placed in the center so that the rails were supported for a distance of 18 in. back from the joint. Simple joint-bars 26 in. long, with six bolts, were used. These ties were fastened to the rail by castings which fitted over the base of the rail and through the steel plates (which had been previously punched) and under the rail. These castings were held in place on one side of the rail by pieces of $\frac{3}{16}$-in. plate, which were placed back of the casting and extended through the plate. The steel tie and the base of the rail were then concreted in the usual manner. This type of construction has proved very satisfactory for tracks on which 45-ton cars are operated.

The work described by Mr. Polk does not deal with the most important part in the making of a good joint for paved streets, although he may have taken care of this properly. When bolts are used, the holes in the web of the rail and in the joint-bars should be of the same size as the bolt, and machine-bolts should be used, making a driving fit. The ends of the rails should be ground so that they will fit tightly, especially at the ball. The drilling should be such that when the bolts are in place the ends of the rails will fit tightly together. This type of joint allows for no change of length in the rail due to change in temperature; but this is not necessary owing to the fact that in paved streets only a small portion of the rail is exposed to extreme changes in temperature, and the tendency to change in length is taken up in internal stresses.

Any open joint will permit the wheels of a car to pound, and this will increase until the ball of the rail is ruined. This pounding may be maintained at a minimum, even in open joints, by keeping the rails ground so that they are of the same height at the joint.

Another cause of pounded joints, and one which will produce failure just as surely as an open or loose joint, is difference in the height of the rails. Specifications for rails allow for a possible variation in height of $\frac{3}{64}$ in. at any joint, and even if the joint is tight in the bolts and the rails well fitted, a pound will start, and there will be cupped rails in the track in a surprisingly short time. For this reason, the joints of new track should be ground to an even surface just as soon as possible after the work is completed.

In track constructed as described, the writer has seen joints which were ground soon after the work was completed, and it required a rather close inspection of the ball of the rail even to find where they were.

Mr. Mitchell.

The writer's work, however, is not of concrete beam construction; in some cases there is concrete under the whole track, and in others the track is on broken-stone ballast with concrete from the bottom up to 2 in. above the top of the ties. The track constructed by both these methods and with joints of the type previously described, has required no maintenance whatever since it was installed 1½ years ago, but it was found that, in some cases, even with the tight joints, the rails had cupped, due to the difference in height, and it was necessary to grind the joints to an even surface.

Another method of constructing a tight joint is similar to that described, except that rivets are used instead of bolts, thus assuring a tight fit between the rail and splice-bar.

AMERICAN SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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THE FLOOD OF MARCH 22D, 1912, AT PITTSBURGH, PA.

Discussion.*

BY MESSRS. L. J. LE CONTE, AND WILLIAM R. COPELAND.

Mr. Le Conte.

L. J. LE CONTE, M. AM. SOC. C. E. (by letter.)—The writer is deeply interested in this paper, because the general scheme for flood control therein considered was, in his younger days, a pleasing day-dream which haunted him for years. Long experience in this line of thought, however, has brought a realization of many practical difficulties which cannot be easily adjusted. The author says:

> "The system of storage reservoirs could be operated primarily for flood prevention during the flood season, and for increasing the low-water flow during the low-water season."

This is perfectly feasible, and true in every respect, provided every private or quasi-private interest is prevented from interfering with free and untrammelled operation in the interest of flood control purely.

The author also states:

> "The benefits to navigation, sanitation, water supply, and water power, which would result from such an improvement in stream regimen would naturally be very considerable."

This is exactly where the fundamental difficulties of the whole scheme come in. Experience everywhere shows that it is almost impossible to reconcile private interests and flood-control interests in one and the same scheme. The conflict is irrepressible, and, in a majority of cases, the combined scheme is utterly impracticable. A single instance is sufficient to show the true nature of the irrepressible conflict. The same reasoning will apply to any one of the seventeen reservoirs proposed.

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* This discussion (of the paper by Kenneth C. Grant, Assoc. M. Am. Soc. C. E., published in August, 1912, *Proceedings* and presented at the meeting of November 6th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Le Conte. Complete flood control requires that all the storage reservoirs shall be practically empty just before the expected peak flood arrives, say, in February and March of each year. This will furnish the desired storage room for the great rush of flood-waters, and everything will work satisfactorily. On the contrary, how does this requirement affect private interests? Water-supply and water-power interests both demand that the reservoir shall be filled as early in the wet season as possible so as to be absolutely sure of a full reservoir before that season is over. This means that the expected great "peak flood," which comes in February and March, will rush down the river and into a full reservoir, pass over the crest of the dam unrestrained, and continue down stream just exactly as it did before the dam was built. As a result, the flood height in the lower river would be the same as before the reservoir system was built, if not greater, inasmuch as the proposed improvements are supposed to raise the low-water plane of the river to some extent.

From this it is clear that, as a rule, flood-control schemes cannot be combined with such schemes as water supply, water power, irrigation, etc., on account of conflicting interests which are almost insurmountable. This is the principal reason why this truly fascinating problem has remained dormant for sixty years or more, and has never received a practical solution.

The writer ventures to submit a few mild suggestions, which, of course, pass for what they are worth. Where the flood-danger period does not extend over 2 or 3 months each year, the storage reservoir waters could be used for power or water-supply purposes during the remaining 9 or 10 months. During the 2 or 3 months when the storage reservoirs must be kept practically empty—in anticipation of the great peak flood—all the power plants and water-supply plants must necessarily be kept going with auxiliary steam plants erected for the special purpose. The long transmission lines in California generally have auxiliary steam plants in the cities where they sell their power and light. These auxiliary plants are started up whenever there is a breakdown on the main transmission lines; therefore, a stoppage of 2 or 3 months at the main power-house is not vital. Likewise, in the case of a water-supply company: if the natural flow of the stream above the reservoir site, in February and March, is sufficient for water-supply purposes, all well and good, and no steps need be taken for an auxiliary supply; but, if it be short of requirements, a small auxiliary steam pumping plant could be located just below the dam site, the pump wells being fed by underground seepage from the reservoir above. The capacity of this plant need be only sufficient to cover the deficiency.

Mr. Copeland. WILLIAM R. COPELAND, ASSOC. AM. SOC. C. E. (by letter).—Mr. Grant evidently prepared his paper with the idea of proving that the construction of storage reservoirs on the water-shed of the Allegheny

Mr. Copeland.

River will protect the residents of Pittsburgh and vicinity from damage by flood. He seems to have overlooked an important matter in this connection, and that is the question of the effect which may be produced on the Allegheny by the storage of acid waters from coal mines in such reservoirs.

Consider, for example, the proposed reservoir on the Loyalhanna. This river, rising on the western slope of the Allegheny Mountains, flows northwestward for about 30 miles until it joins the Conemaugh at Saltsburgh, forming the Kiskiminetas. From its source to Latrobe, it lies in a rather broad, open valley. Between Latrobe and Saltsburgh, however, it winds through a valley, so narrow and deep in many places that it becomes a gorge.

This valley is crossed at four or five places by dikes of stone which form natural dams, and they have been raised in height artificially for the purpose of storing water for mill powers. The pools thus formed—each a mile or more in length—serve as catch-basins for the mine drainage entering the stream from each side.

This mine water has several marked characteristics, one of which is that its specific gravity is greater than that of ordinary surface water. Therefore, the drainage drops to the bottom of the river, collecting, of course, in the pools above the dikes. Another bad feature of mine drainage is the free acid and acid salts which it contains.

Chemical analyses have shown that water flowing from coal mines in this region carries from 100 to 500 parts per million of free acid. Dilution and reaction with the alkaline carbonates carried by the surface waters tend to reduce the acidity, but, nevertheless, a sample of water taken from the bottom of a pool in the Loyalhanna in September, 1899, contained 200 parts per million of free acid—and the sample was taken just after a considerable flood had passed down the stream.

July, August, and the first half of September had been very dry, but about September 15th a thunder-storm having the characteristics of a cloudburst broke upon the upper water-shed. So great was the rainfall that the run-off raised the river more than 2 ft., creating a current in the Loyalhanna which swept the immense volumes of acid mine drainage stored in the pools into the Kiskiminetas, and eventually into the Allegheny.

Millers and farmers have complained for years that the mine waters of the Loyalhanna eat up their iron water-wheels, and poison stock which drink from the stream. One man told the writer that he had lost a 1-in. iron crow-bar through the ice on the river during the preceding winter, and that by spring the bar had been eaten in two.

The head-waters of the Loyalhanna contain fish, frogs, lilies, and

Mr. Copeland.

all the natural aquatic life of the region; but below the entrance of the first coal-mine drains, at the outskirts of Latrobe, not a fish nor a weed can be found in the water.

When the mine water—swept into the Kiskiminetas by that September flood—reached its month, the acid burned the legs of Italian laborers working on a bridge pier, and drove them out of the river. Passing into the Allegheny the sulphur water killed tons of fish in its run of 40 miles to Pittsburgh, and the rotting bodies created such foul conditions that the Superintendent of the Pittsburgh water supply at once started an investigation regarding the cause of the death of the fish.

Smaller floods of this character are of common occurrence in the Allegheny, and are becoming more common annually. The volume of mine water is increasing, too, as new coal mines are being opened yearly, the workings in others are being extended, and last, but by no means least, the drainage from all former openings continues to pour unceasingly into the watercourses.

At present the dikes and dams are so low that the Loyalhanna is flushed out several times a year, but what will happen if a great reservoir is formed by throwing a dam across the stream near its mouth, as indicated on the plan, Fig. 2. Such a structure will surely store the acid mine drainage, and, if any exceptional flood, from a cloudburst or other severe storm, sweeps the water out of the reservoir, far greater volumes of stronger acid water will be poured into the Allegheny than has ever entered it at one time before.

When this happens, the water consumers in all the towns on the river, and the men in charge of the water purification works at Pittsburgh and elsewhere, may well take heed lest the mine drainage destroy their boilers and water mains, and even close the water-works plants temporarily.

The location of the dam on the Loyalhanna has doubtless been chosen in order to get a maximum amount of storage and to decrease the danger of flood from this region to a minimum; but, in view of the presence of mine water on the lower water-shed, is it advisable to locate the dam at the proposed site? Would it not be better to build the dam above Latrobe, for instance, at Ligonier? Part of the town, a railroad, and some highways would doubtless be wiped out, and the volume of water stored would be reduced. Some persons might argue, further, that the process of holding back the alkaline surface water at Ligonier would cause a more concentrated sulphur water to flow into the Allegheny. This effect could be easily remedied by opening gates at the dam, and really improve present conditions by keeping a larger and more uniform flow through the lower valley at all seasons.

Mr. Copeland.

If the dam is ever built at the site proposed in Fig. 2, channels should be cut through all the present dikes to drain the heavy acid water from the lower parts of the pools; and blow-off gates should be placed in the bottom of the dam through which a constant discharge of water will be maintained for the purpose of preventing the acid mine drainage from destroying the gates or even injuring the structure itself, as well as the city mains and plants on the lower rivers.

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PAPERS AND DISCUSSIONS

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STATE AND NATIONAL WATER LAWS, WITH DETAILED STATEMENT OF THE OREGON SYSTEM OF WATER TITLES.

Discussion.*

By Messrs. Clarence T. Johnston, L. J. Le Conte, George L. Dillman, W. E. Moore, Morris Bien, Horace W. Sheley, and Morris Knowles.

Mr. Johnston.

Clarence T. Johnston, M. Am. Soc. C. E. (by letter).—This paper deserves some comment from those who are interested in problems of stream control. The writer is glad to find, here and there, an engineer who has had sufficient experience in such work to convince him that the questions which arise are of a legal nature only in an incidental way. In its fundamental aspects, the supervision of water resources is of greater public concern than the protection of land titles. Water and watercourses are generally considered as public property, and, therefore, the demand for an engineering administration has not been felt, except where streams have been used to a large extent, and particularly where water has been diverted from natural channels. As controversies have arisen, the Courts have been appealed to, and to-day, particularly in the West, decisions of all kinds are made. Volume after volume is published dealing with theories which have been developed and played with by attorneys, until they can no more be applied in practice than water can be diverted from a stream without affecting its discharge.

We derive our common law from England. With that law we brought the doctrine of riparian rights, which guarantees to every owner of land abutting on a watercourse the right to demand that

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* This discussion (of the paper by John H. Lewis, Assoc. M. Am. Soc. C. E., published in September, 1912, *Proceedings* and presented at the meeting of November 6th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Johnston. the waters thereof pass his property "undefiled in quality and undiminished in quantity." This is the true riparian doctrine. It is not suited to a country where large volumes of water must be taken from the streams. Regardless of this and regardless of the experience of other countries, lawyers and Courts have tried to make it fit every climate and every natural condition. A simple doctrine, which suits a country where large rivers prevail and where actual diversions are of little importance, has been distorted and juggled with by the Courts until it is no longer recognizable. The "modified" doctrine of riparian rights, as we have it inflicted on us, is often a convenient screen for crimes committed against the public and in behalf of those claiming "vested rights." A perusal of the statutes of various States referring to riparian rights, and quite generally the laws pertaining to stream control, will disclose the existing situation to the student. Much has been done to protect vested rights, but reference is seldom made to public rights. The idea that the public ever obtains a vested right would never be gleaned from reading the statutes dealing with stream control in a majority of the States. This condition arises from the fact that the lawyer, representing those who claim many special rights and privileges, often reaches the Legislature where he exhibits marked ability in inserting such clauses as the following: "This chapter shall in no wise be construed as impairing or abridging any rights already vested in any person or persons, company, or corporation, by virtue of the law heretofore in force." After a training of this kind he develops an instinct which enables him to protect private property rights without study or deliberation. Should such a man be elevated to the bench, he displays the same tendencies, and some of our remarkable decisions may be attributed to Courts so constituted.

Streams and lakes are not like land, in so far as private possession is concerned. Land can be measured and privately controlled. Water is constantly shifting, and the supply changes every day. The public must bridge streams and provide harbors. The public must protect fish and provide for the safety of dams. We use water to-day only to lose it to-morrow when it runs on, a continuous blessing to the public. It cannot be owned privately, and no State should ever permit individuals or corporations to claim such ownership. It is plain that injustice would be worked should one nation have exclusive ownership of one of the great oceans. It is equally plain that injustice would result should one State control an interstate stream or lake. The same rule applies when one individual or corporation is permitted to assume control of any local water supply, yet the local public is often slow to act in its own defense. The engineer should appreciate these facts. He should be a leader in questions of stream control. Unfortunately, engineers have not assumed the responsibility that naturally belongs to their Profession. We may criticize the Legal Profession

Mr. Johnston.

and the Courts—and possibly they deserve it in some degree—yet we must remember that the engineer is depended on for information; and further, that where engineers have studied these important problems and given the Courts the results, reforms favoring public control have begun to appear. Too many engineers have been blinded by what seems to them to be the best policy at the time for their employers who appeal to the Courts. Too many engineers fail to see that principles which insure justice to the public protect water users generally. The water rights of private users are best insured where public control is most rigid. Engineers have been as tardy as the Courts in recognizing this.

When the National Constitution was framed, the States ceded to the General Government the control of navigable waters. The nation, as a matter of development and defense, must control navigation when necessary. Non-navigable streams remain in the possession of the States. The States have not properly administered the smaller streams which they own. It has been so apparent that streams and lakes are naturally property of a public character that, for a long time, particularly in localities of large rainfall, the necessity for public supervision has not been called to the attention of lawmakers. Regardless of the public character of streams and lakes, private interests have assumed to take possession here and there, and the claims thereby arising are still to be settled. The great questions relating to State administration of waters are yet to be determined. Some Court decisions would appear to be final and in favor of a private monopoly of public property of this kind, yet the end has not been attained in a single important case.

Because the States have been slow in asserting the doctrine of public rights in property which is essentially of a public character, we need not fear that the public has lost title in any way. Because some individual or some corporation has been using this property for a term of years, there is no reason to hold that the users have secured title thereto. It would seem that such users would owe the public a vote of thanks at least. Many troubles have been precipitated because the owners of riparian lands have been permitted to claim more than the true riparian doctrine would admit in itself. Because the General Government has not meandered every small stream—a physical impossibility—the subsequent patentee of riparian lands has assumed that he owns the land to the center or entirely across the channel of the natural waterway. Where, through ignorance of the naturally public character of streams, the Courts have seemed to confirm claims of this nature, an error has been made, but such errors will be corrected in time.

Water must be used by individuals and by corporations. The public should realize this and consent thereto. The public and all users

Mr. Johnston. should appreciate the difference between the use of water and the ownership of water. All uses should be of such character, and secured under such restrictions, that the authority and ownership of the public are manifest in every transaction and apparent to all concerned. When the time comes for the public to assume full control of its property, private interests should be recompensed according to the estimated cost of replacing the works constructed by them, and which, under the new order of things, are to be operated by the public. Valuation work of this kind has also fallen largely to the engineer. It is a new science, and engineers have not reached an agreement as to the principles which should be applied in determining just valuations.

Principles are of so much more importance than details of law, methods of procedure, or exact character of administration, that the writer does not feel inclined to discuss National, State, or even more localized control of streams. Under present conditions, there can be no question as to the responsibility of the General Government and of the States in work of this kind. The essential facts which should determine any question which may arise are of an engineering, rather than of a legal, nature. They are simple and, as a rule, not difficult to obtain where an engineering administration is provided.

The writer has followed the development of the public control of streams of the West for many years. Wyoming, under the able leadership of Elwood Mead, M. Am. Soc. C. E., took the first step which relieved the Courts from all initial proceedings in questions relating to the use of water. Only appeals from administrative officers go to the Courts in that State, and these appeals are so few that during the past twenty years they can be counted on the fingers of the two hands. During that time the State Administration has studied and determined more than 15 000 claims and, at the same time, has protected all public rights. As Dr. Mead's Assistant for a term of years, and as State Engineer for nine years, the writer was able to give some thought to the principles which should underlie the laws relating to stream control, and the following matter from his last report* to Governor B. B. Brooks contains a discussion of the elementary principles:

"Some reference should be made at this time to Sections 724, 725, and 726, Wyoming Compiled Statutes, 1910. These sections were added to the irrigation laws of the State by the Legislature of 1909. The bill before the Legislature was known as 'House Bill No. 66.' All who have studied this legislation agree that it represents the most important action of the law-makers of the State since the original statutes were enacted in 1891. While the purpose of the act is fresh in the minds of those who were in the Legislature and among those who prepared the bill, some public record should be made of its purpose so that when its provisions are interpreted, there will be no mistaking its object.

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* Biennial Report of the State Engineer to the Governor of Wyoming, 1909–10, pp. 17 to 29.

Mr. Johnston.

"The Act reads as follows:

"CHAPTER 58.

"*Water Rights.*

"724. *Water Right Defined*: A water right is a right to use the water of the state, when such use has been acquired by the beneficial application of water under the laws of the state relating thereto, and in conformity with the rules and regulations dependent thereon. Beneficial use shall be the basis, the measure and limit of the right to use water at all times, not exceeding in any case, the statutory limit of volume. Water being always the property of the state, rights to its use shall attach to the land for irrigation, or to such other purpose or object for which acquired in accordance with the beneficial use made and for which the right receives public recognition, under the law and the administration provided thereby. Water rights cannot be detached from the lands, place or purpose for which they are acquired, without loss of priority. (L. 1909, ch. 68, Sec. 1.)

"725. *Preferred Uses Defined.* Water rights are hereby defined as follows according to use: Preferred uses shall include rights for domestic and transportation purposes; existing rights not preferred, may be condemned to supply water for such preferred uses in accordance with the provisions of the law relating to condemnation of property for public and semi-public purposes. Such domestic and transportation purposes shall include the following: First—Water for drinking purposes for both man and beast. Second—Water for municipal purposes. Third—Water for the use of steam engines and for general railway use. Fourth—Water for culinary, laundry, bathing, refrigerating (including the manufacture of ice), and for steam and hot water heating plants. The use of water for irrigation shall be superior and preferred to any use where turbine or impulse water wheels are installed for power purposes. (L. 1909, ch. 68, Sec. 2.)

"726. *Change to Preferred Use.* Where it can be shown to the board of control under the provisions hereof, that a preferred use is to be made, the procedure for a change of such use shall embrace a public notice, an inspection and hearing if necessary by and before the proper division superintendent, a report of such superintendent to the board of control, and an order by said board. If the change of use is approved, just compensation shall be paid and under the direction of the board, proper instruments shall be drawn and recorded. (L. 1909, ch. 68, Sec. 3.)

"The act is plain in its terms. There may be some confusion, however, in the minds of those who have not followed the history of the development of irrigation law in this State. The constitution of the State which has the approval of Congress, says:

"'Section 1, Article VIII. The water of all natural streams, springs, lakes or other collections of still water, within the boundaries of the State, are hereby declared to be the property of the State.'

"This provision of the constitution has been discussed from various standpoints. The State has never held that the water which it owns should be disposed of for profit. It is not deemed wise to administer this natural resource for revenue. It is presumed by the law-makers of Wyoming that the water the State possesses is for the use of the

Mr. Johnston. people. However, the State has a greater responsibility. Wyoming has discovered and placed on the statutes of the State the first definition of essential principles that should govern the use of water. So that the State, not only owns the water and permits of its use without charge to her citizens, but the State sees to it that all users are given equal protection. One man cannot be permitted to expand his use without interfering with the rights of a community. The State early discovered the danger of permitting water or water rights to be treated as personal property. If water rights are owned separate from the land irrigated, or such other use as may be made of the water, then the personal element enters and there is no such thing as public supervision and no such thing as the protection of the community against the greed of a few who may be powerful or influential.

"We cannot review the decisions of the Colorado courts without feeling that they have failed to enunciate such doctrines as will protect the water user. For instance, we find in the case, 'Laramie County Res. Co. *v.* People *ex rel.* Luthe,' 8th Colo. 614, the following definition of 'appropriation.' 'Appropriation is the intent to take, accompanied by some open, physical demonstration of the intent, and for some valuable use.' The court evidently understood that a diversion from the stream without actual beneficial use of water could not give the right to use water. It was manifestly plain to the court that there was something necessary in addition to a claim, which we assume to be the manifestation of the 'intent.' The court did not see that an investment in irrigation works can be protected without giving the investors ownership in water. It saw that a time must lapse between the filing of the claim, or the expressing of the 'intent,' and the use of the water. Hence the priority would date from the time the claim was filed. The company, unless disturbed by some agency, would secure title to water under that priority date providing it completed the irrigation works. There was no limit to the demands the company might make on the stream, except its financial ability in ditch and reservoir construction. There was nothing in the plans submitted to tell where the prospective beneficial use was to occur and absolutely nothing to protect those who were to be the actual water users. It might have occurred to the court that the State could by law provide that a company be given a certain time to show its good faith and upon the final showing being made, that it be given a certain time to sell interests in the irrigation works constructed. It might have occurred to the court that this would have enabled each water user to have obtained water rights dating back to the time the claim was filed in some office of public record; it would have enabled the company to have obtained a reasonable profit; it would have left the water rights in possession of the water users, each having an interest in proportion to the land reclaimed; it would have given the irrigation works to those who should for all time rightly be held responsible for maintenance. How the construction of irrigation works without any arrangements being made with prospective users or without any reference to the proposed beneficial use, can give the builders a right to the water is a problem that is too complicated for the average man to grasp. The court saw the danger ahead and it tried to do something to avoid it. The trouble was that the court gave the company every-

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thing in sight, under certain conditions. It is like giving a railroad an entire valley on condition that transportation facilities be provided. The railroad has a right to demand lands which it uses or is to use. The ditch company has this right. Water is more valuable than land. The railroad company is not entitled to all the land in sight, when it cannot use the land. The ditch company cannot use all the water it can divert. It has no right, therefore, to be placed in position where it can sell water which it has never acquired by beneficial use. A railroad company which secures an entire valley receives a rich reward. It can sell the lands to those who can cultivate them. This arrangement should be very pleasing to the railroad company. It was doubtless as pleasing to the ditch company to get title to water. It could sell this water to those who either had to buy it or face financial ruin. There is absolutely no reason why an irrigation company, or any individual, should have title to any property except the physical works it constructs or acquires. The court did not see this. It did not see how the water users could be protected under the priority obtained by the initial filing except by giving the company title to the water. This is so simple and it works out so easily where the States have an administrative system which manages streams for the benefit of the public, that any other plan would never be discussed if it were not that living examples of a dangerous type are so close at hand. The Colorado court decisions go a little further than to give everything to the company which builds the irrigation works. The rights of the consumer are discussed in a number of cases. This admits of some intimation of rights that others, aside from the irrigation company, might hold. If the court, in the first place, had held that the plans submitted by the company must be based on good engineering and that specifications for every structure must be filed; if it had then compelled the company to designate the lands that were to be reclaimed and dedicated the water to the benefit of those lands, a foundation would have been laid that would have supported every principle that might be necessary to protect those that were to follow the company. There is a library of speculation over this subject of appropriation in the Colorado decisions—yet no two complete discussions are in entire harmony. All indicate that there is something that should be reached and in every decision this something is just beyond the grasp of the court. To prevent too much injury being done the water users, the State Legislature has given the county commissioners authority to regulate the price paid for water. Because the court could not fathom the problem before it, the future of every project is left with administrative officers, who may or may not be able to determine what price is fair. The county commissioners may be connected with the company and they may be water users under the system in question. It would seem much better to make the water rights attach to the land and establish the price which the water user is to pay for an interest in the irrigation works in the beginning.

"Let us study an individual case so that its history may be approximately complete. The Colorado courts dealt out water, rather than water rights, with a lavish hand. The courts did not know what volume of water was necessary to satisfy with justice the needs of each claimant, and they did not know what principles should govern

Mr. Johnston. in the adjudication of rights. No person can arrive at any other conclusion after reading closely the court decisions of the State. For instance, a water claimant is given a right to 35 cubic feet of water per second. The court does not say that this water belongs to the land or that the water right belongs to the land, but the person is given a kind of title to so much water. As the country grows the person so favored finds that the court has given him a large volume of water that he has never used. He therefore applies for a change in point of diversion. This may be opposed in the courts, but he generally wins out. He then proceeds to use this water on new lands, water that others have for years past been using. Those who are injured may be able to protect themselves if they have means. If not they must suffer the consequence. This person, who is so fortunate to get possession of water that he has never used, then proceeds to use it in another way that injures the community still further. Because the court has given him 35 cubic feet of water, he holds that he can store all of the excess that he does not need in the irrigation season for direct application from the stream. This is a happy thought. In the meantime possibly enough reservoirs have been built to store all of the excess flow of the stream. This makes no difference to this fortunate person. He stores, for his own use and for speculation, 35 cubic feet of water per second, except during the irrigation season, thus depriving other persons of his community of water that they have been using.

"He has probably secured the 35 cubic feet of water per second when he only irrigated 160 acres of land. Two to two and one-half cubic feet per second during the irrigation season would be ample for this area. Even should he be able to apply three cubic feet per second, he would have left 32 cubic feet per second for speculation during the irrigation season. This would supply water for 2 000 acres of land and be worth $80 000.00 at least. By storing 35 cubic feet per second for nine months he would impound 18 900 acre-feet of water. If a fourth of this, or 4 725 acre-feet of water are lost by seepage and evaporation, he would have left 14 175 acre-feet of water for further speculation. This would irrigate fully 6 000 acres of land and be worth $240 000.00. The court, therefore, through ignorance, and without considering the rights of any person except the claimant, gives him $320 000.00 worth of water that he has never used and which has been used by others. This value of $320 000.00 cannot be given to one claimant without taking it from another.

"What is the situation in Wyoming? An agricultural community begins to develop. Each applicant for water rights obtains permits which describe lands to be irrigated. The water rights are finally adjudicated and dedicated to the use made. The water used for irrigation belongs to the lands reclaimed. It remains attached to that land. When the land is sold it goes with the land. The law places a maximum limit on the use that can be made—one cubic foot of water for each seventy acres of land irrigated. The public must see to it that waste does not occur. This maximum limit cannot be exceeded at any time and the use is restricted to such volume less than the legal limit as can be beneficially applied to the lands to which the water right attaches. There is no way to expand the use. There is no way by

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which an individual or a company can speculate at the expense of a community. All rights are matters of record and there can be no serious cause for dispute.

"Because certain lands have water rights direct from the stream during the irrigation season does not mean that these lands are entitled to water throughout the year. The first reservoir built in compliance with law secures the first right to store water to its capacity. This reservoir can be filled at any time that the stream furnishes a supply that is not used. The second reservoir then has its turn, and so on. Reservoirs store water—not water rights. Ditches carry water—not water rights. Water stored in reservoirs simply augments the supply during the season when needed and this water leads to the perfection of water rights which belong to the lands reclaimed and to the other uses made, the same as though the stream supplied an ample volume during such seasons.

"Section 724 states that 'beneficial use shall be the basis, the measure and the limit of the right to use water AT ALL TIMES not exceeding, in any case, the statutory limit of volume.' This means that when the community needs protection the public control must be such as to limit all users to the volume that can be beneficially applied. The certificates of appropriation, issued by the Board of Control, describe the lands to which the water right belongs and specifies what the maximum allotment of water is to be. It also says in conformity with the law that the use shall consist of the application of such part of the maximum allotment as can be beneficially applied.

"Water is the property of the State and no charge is made for its use. When water is used for irrigation or for any beneficial purpose for a term of years, the user should feel thankful to the public that conditions are such that he has been able to do business without being subjected to a special tax on the water. Because the public has enabled this to be done, is there any reason why any person or company should be given the additional right to sell the water or water right he has been enjoying? The community cannot be injured as long as the use continues as it has always been, but that use cannot change without having some effect on the rights of others. Because the last sentence of Section 724 states that water rights cannot be detached from the lands, place or purpose for which acquired without loss of priority, it is held by some that the act is unconstitutional. Under the constitution cities and towns can condemn water rights for municipal purposes. When a city or town needs water it gets it and always gets it regardless of priority or the character of the right. Under this same act, municipal uses are made preferred uses. It may often serve the purpose of a town to condemn a water right that belongs to some land not enjoying an early priority. For instance, the early rights may all be near the source of a stream. This is an ideal condition. The town may be twenty miles below the lands having these rights. There may be irrigated lands near the town that can be condemned to furnish a water supply for the municipality. The water right obtained by the city or town under such circumstances cannot affect the early rights at the head of the stream, yet the town has secured an adequate supply. Should it be necessary to condemn one of the early rights at the head of the stream, this could be done, at any time later.

Mr. Johnston. The idea is this—nothing should be done by the State to give an added value to the early rights. There are so many conditions affecting the flow of a long stream, that cities and towns can often be supplied without interfering with the early irrigation development. A town might buy an adjoining farm with whatever water rights it may have. If the use of this water for municipal purposes will injure other water users, outside of the town, then they should be recompensed. After a city or town buys water rights, they become preferred uses, so that the priority of the right makes but little difference. The main object is to see to it, at the time the transfer is made to the town or city, that all who might be injured by this change are taken care of at once. Section 726 provides that these changes shall take place under the direction of the Board of Control. This means that an inspection will be made by the Superintendent, all users will be notified and the final record will embrace a settlement that will be in harmony with physical conditions and with justice to every allied interest in the stream. One thing should be remembered—preferred uses are to be protected in seasons of scant water supply. When a change is made of any inferior right to a preferred use, all who might be affected should be made acquainted with the purpose of those who represent the preferred use and all precautions taken while the matter is before the board to secure whatever redress may be justifiable. It should also be remembered that preferred uses require small quantities of water compared with uses for irrigation. For instance, suppose a man owns 160 acres of land to which a water right attaches. Assume that he covers this to a depth of two feet during an irrigation season of 90 days. This is 320 acre-feet of water, or 104 544 000 gallons. This volume of water would furnish a water supply for a town of 3 000 people for a year, estimating that each person requires 100 gallons of water per day of twenty-four hours. Since the irrigator does not use water from the stream, except during the irrigation season of say 90 days, he has no right to the water during the remainder of the year. The town can file an application for the necessary supply outside of the irrigation season and the permit secured gives rights that cannot interfere with the rights of any other user, unless other rights have been secured which depend upon diversions outside of the summer season. The water right for 160 acres with the additional flow that could be secured under permit would supply a town of 12 000 people, if the water could all be used without loss. Certainly this should be a preferred use. The value of a city of 12 000 people to the State and to the public as locally represented, is far in excess of the value of any 160-acre farm, no matter how highly it may be cultivated.

"Another point should not be overlooked in this connection. The State does not permit the use of the legal maximum flow—one cubic foot per second for each seventy acres of land reclaimed, except when this volume can be beneficially applied. The owner of irrigated land cannot charge except for the value of the land with a water right, compared with the land in its former arid condition. He cannot, in other words, transfer to a municipality or to any preferred user, the maximum limit of his water right. This must be fixed by the board of control at such hearing as it may conduct. The city may buy the land outright and the entire tract of say 160 acres may be irrigated. The land may be of such character that one acre-foot per annum will raise crops and this volume may have been the maximum that has ever been used. Manifestly this is all the municipality obtains. Mr. Johnston.

"It is believed by those who understand natural streams and the effect of diversions therefrom that it is much better to permit preferred users to purchase any rights that may be available rather than to place a premium on the first right, as has been the custom. For instance, if the first right were at the head of the stream and the city at or near its mouth, the irrigators above would lose all return seepage from the lands irrigated under the early right should this be transferred to the municipality. The early right and all other rights might continue undisturbed should it be possible for the town to secure a comparatively inferior right nearer to its boundaries.

"This legislation was not prepared on the spur of the moment. It represents the result of many years of study. It received the consideration of irrigation authorities throughout the West. It was given very careful study by the committees on lands and irrigation and by individual members of the Legislature of 1909. This act does not represent the personal views, only, of any individual or by any class of individuals. It represents in concrete form the wisdom of water users, students of irrigation and legislators. It passed the Legislature of 1909 with but seven dissenting votes altogether. No attempt was made to frame a measure of the kind until the views of the water users of Wyoming had been obtained. The responses received to letters mailed to thousands of irrigators throughout the State laid a foundation for the bill as it was submitted.

"It has been said that other States and that courts do not recognize the principles embodied in this act. It must be admitted that Wyoming stood for something of the kind long before any such doctrines were heard of outside of the State. It must be admitted that because other courts failed to get down to the proper fundamental principles, our courts had no guide, except in so far as our law-makers prepared the way. However, these doctrines are spreading. We need not search in vain for decisions that have the fundamental principles clearly defined. On March first, 1910, a decision was handed down in Arizona which should be read in full by every student of irrigation. The title of the case is 'Patrick T. Hurley, the United States, Intervenor, *vs.* 4 800 other water users.' It relates to the settlement of claims to use water from Salt River. The Reclamation Service is constructing one of its large projects in the valley of this stream, hence the United States intervened in the suit. The Supreme Judge of the Territory, acting as District Judge, heard the evidence and made the decision. It is remarkably complete. The definition of principles appearing on pages 8 and 9 of the printed copy of the decision is worthy of careful study and consideration. We quote this in full as follows:

"'The doctrine of riparian rights does not obtain in Arizona. The right of the owner of land to divert from a natural non-navigable stream the flow of water therein and to apply the same to beneficial use upon such land, is and always has been recognized in this territory. Such diversion and use is termed an appropriation of water. Whatever may be the steps necessary to take to initiate such a right or to evidence the intent to initiate it, the appropriation itself only becomes complete

Mr. Johnston. and vested when the water is actually diverted from the stream and placed to a beneficial use upon the land. The right given by such an appropriation is strictly not a right to the water itself, but a right to the use of the water. Its application to a beneficial use upon the land is as necessary in order to complete the right as is the diversion thereof from the stream. An appropriation of water, therefore, for the purpose of the irrigation of a parcel of land may not be established and completed by means merely of a declaration of intention or by the posting of notices of appropriation, nor may it be made by a canal owner or by a canal company as such alone, independent of its ownership of the land; but as application to a beneficial use upon the land is necessary to complete the appropriation, it follows that such appropriator must be an owner of land or have a possessory right thereto. Furthermore, since the land to which the water is to be applied is a necessary integral part of the appropriation and a factor by which the amount of the water appropriated for use is measured, it follows that when the water is no longer applied to the land for which it was diverted, the right of appropriation of such water for such land ceases. The right of appropriation further depends upon a supply of water that is unappropriated. It follows, therefore, that the first in time of appropriation is the first in right to appropriate, since water previously appropriated by another is no longer available for a subsequent appropriator. The extent of the appropriation is limited by the beneficial use to which the water can be applied. The actual amount of water that may be appropriated for irrigation, therefore, is the amount that the land owner can and does actually use in the necessary and economical irrigation of his land for cultivation. This much and no more may he have; and this much he may only have when there is sufficient water available to supply first those prior in date of appropriation. The fundamental principle in the doctrine of appropriation of the normal flow of water in a stream for irrigation is its application by the land owner to the land for a beneficial use. The right to appropriate is a right that belongs to the land owner, but the water appropriated is appropriated for the land, and when so appropriated its use belongs to the land and not to the appropriator. The method of diversion from the river and the means of carriage of the water to the land is immaterial in the establishment or maintenance of the right; it may be done by the individual appropriator or by an association of individual appropriators, or by a canal company, or by any person or corporation; and the means of carriage or the point of diversion from the river may be changed from time to time to suit altered conditions without impairing the right of appropriation already made, provided prior rights of others are not interfered with. There being in this territory no private property in water, but water being a public property subject to the uses before defined, in so diverting and carrying the water such person, association or corporation acts merely as the agent of the appropriator and acquires no right of appropriation to the water itself, and no rights as against the appropriation made to the land, except a right to proper compensation for such diversion and carriage.'

"This decision marks distinct progress in court decisions relating to the use and diversion of water from natural streams. The principles

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upon which the decree is rendered afford protection to every claimant yet when they are applied in practice no man is given a weapon whereby he may destroy the prosperity of his neighbors. The personal element is eliminated. The welfare of the community, through the protection of each individual in accordance with the nature and extent of beneficial use of water, is taken as the criterion for the settlement of rights rather than the claims of individuals regardless of the character of the irrigation development they may have been responsible for. Because the federal government intervened in this case and because the judges were at the time federal officers, the decision has a value that is more far-reaching than would ordinarily be the case. The entire decision is recommended to the consideration of those who are interested in the settlement of water right claims and controversies.

"It has been held by those who do not support the principle which unites water rights to the land reclaimed that the act of 1909 does not apply to water rights which were perfected prior to the passage of the law. This is the old argument that supports 'vested rights' regardless of the welfare of the public. The public and communities generally will protect individuals in their rights if the public and the community is made supreme over the individual. If the individual is superior he will take advantage of his position to injure the community. If the State cannot make laws affecting the administration of its own property, then it certainly cannot enact statutes which have for their purpose the collection of taxes, for instance, which relates to the raising of revenue from property in private possession. It cannot quarantine live stock belonging to private parties even for the protection of communities. It cannot pay bounties for killing predatory wild animals or defray the cost of protecting game animals. To say that the State cannot regulate the use of water by the enactment of new legislation, even after water rights have been acquired for various purposes, is on par with the claims of certain people who held that because they began the use of water prior to the admission of Wyoming to statehood, the State had no control. This contention led certain claimants in Johnson County to refuse to submit proof before the Board of Control and to attempt at a later date to secure certain rights by litigation. The case was finally decided by the Supreme Court of the State, 9th Wyoming Report, 110. This decision is plain. It indicates that the State can regulate the use of water regardless of when the claim was initiated or under what laws water was first used. It is not presumed that the Legislature will injure water users by the passage of any general laws. It is not believed that it will ever be necessary to injure any water user to protect a community. It is essential to have water rights defined in such a way that the individual will never presume to have such rights as will enable him to even threaten the prosperity of a community. If no water user has rights in excess of those that attach to his lands as limited by beneficial use, the community need never fear any trouble. The danger in irrigation matters never begins with the community, or the State. It has its birth in the greed of one or two who, through the weakness of supervision in behalf of the public, are able to get what they are not entitled to, thereby enriching themselves at the expense of their neighbors.

"The fundamental principles which provide equal protection to all

Mr. Johnston. and special privileges to none, are so simple and their number is so small, that it is surprising that they are not stated in every irrigation statute and in every text book dealing with the use of water. Yet we look almost in vain for any discussion of them. All that need be borne in mind is that the right to use water should be limited in accordance with the beneficial use made and the right should belong to that use rather than to the user. All other matters relating to the right are questions of fact that are easily obtained."

Mr. Le Conte. L. J. Le Conte, M. Am. Soc. C. E. (by letter).—Every great hydraulic project calling for a large expenditure of money demands the employment of three distinct classes of Man, namely, a good promoter or business man, a good lawyer, and a good engineer. Each of these men attends to his own particular line of business, and, as a final result, the scheme is a success. This seems to be the experience everywhere.

Of late years, however, the universal knowledge demanded of the engineer has grown to such an extent that, in order to be thoroughly up to date, he has to be well nigh omniscient. The time now seems to be fast approaching when the engineer in charge of a large scheme will be compelled to acquire the necessary knowledge of all three of these classes of men.

The author says that Court decisions are based more on the logic of judges than on the statutes. This calls to mind the lamentable fact that almost everywhere all the law that the general public gets, at best, is judge law, pure and simple.

The author calls on the Engineering Profession to come forward and take active lead in the movement for the enactment of better water laws. This is badly needed everywhere, and certainly engineers are, by experience, better fitted for the task than men of any other class.

The author says that many lawyers fear that the reform in water laws would spoil their business, which is true; but it also shows—a well-known fact—that members of the legal profession, as a rule, make their living by feeding on the misfortunes of the public. It is natural, therefore, that they should object to anything that cuts down the business of the Courts.

It is highly desirable that interstate or national water laws should be framed and enacted as soon as possible, inasmuch as all large projects are now halted and waiting for results. The new State water-right laws of Oregon certainly seem to be simple and effective, and, apparently, they fulfill all public requirements very satisfactorily. It now remains to enact similar laws to cover the needs of interstate streams.

It will be remembered that the City of New York contemplated getting a new water supply from the Housatonic River, which, to a large extent, is in the States of Massachusetts and Connecticut. After much wrangling in the Courts, the scheme was abandoned, and the city was forced to go to the Catskills, which project is now being developed on a grand scale. Mr. Le Conte.

The report of the Committee on Interstate Water Rights to the National Irrigation Congress, held at Sacramento, Cal., in 1907, seems to be highly commendable. The equitable suppression of the drastic law of riparian rights seems to be absolutely necessary for the public welfare.

Finally, the writer would respectfully suggest, in keeping with what he has stated before, that the Administrative Board, which will have complete jurisdiction of all matters relating to water, should be composed of good engineers, good business men, and good lawyers, all of whom are reputable citizens. The reason for this is that it is now practically impossible to find one class of men gifted with all these qualifications combined.

The members of such a Board, of course, would shoulder grave responsibilities, and their compensation should be ample, so as to enable them to give their time exclusively to the Board's business.

Mr. Dillman. GEORGE L. DILLMAN, M. AM. SOC. C. E. (by letter).—This paper brings up a subject which is most pertinent and timely. If it results in a solution, more good will have attended it than can be put in dollars and cents, and everybody concerned will benefit: the investing public, the constructing companies, the consumer who ultimately pays the bills—everybody but the professional litigant.

Some years ago the writer was employed as engineer for one of two strong litigants on a water-right case in Southern California. The usual slow course in the Courts was followed for years; a final verdict seemed impossible for years to come. Somebody, at a "psychological moment," suggested compromise, and, as far as the legal adjudication of the case is concerned, it will never be settled. After the case was dropped, one of the attorneys was asked: "What can make a good water right in California?" The reply was: "Nobody has any right to such a thing who is not prepared to fight for it at any and all times. There is no such thing as a perfectly defensible water right."

Two strong corporations in Kern County agreed to disagree over the water rights of Kern River, a large stream with many diversions for irrigation purposes. Their case was in the Courts for several years, during which time the small claimants allied themselves with one side or the other. Many thousands of dollars were spent, and the case was withdrawn without a verdict. The principal litigants agreed to divide the whole waters of the river between themselves, and the small fry were shut out. The legality of the dispute is not settled, but both big companies together stand ready to make it interesting

Mr. Dillman. for all adverse claimants. They have acquired adverse claims by prescription now, therefore, there is no question as to their "rights."

In California there are thousands of doubtful rights, involving millions of dollars, which would be settled if it could be done with small or reasonable expense. The owners of new diversions, changes of use, or changes of point of diversion, are not safe in their investments until their rights are prescriptive. Only a few days ago, one of the leading lawyers of California stated that the best water right to be had was by prescription and continual use, that filing rights and riparian rights were so indefinite that their defense was always doubtful.

There will never be much conflict between uses for power and irrigation in California by reason of the physical conditions, provided the power water is returned to the stream after use. In a large majority of cases the power sites are above the irrigation diversions. Where considerable areas of irrigable land lie in valleys above power sites, their irrigation will generally result in the steadier flow of streams below. Where power necessitates storage to increase low-water volume, this storage will benefit the irrigation below, because the irrigation season is generally the time of low water. Therefore irrigation and power uses can be made mutually beneficial.

This same question is international in places. Recently, the papers announced that the Mexican Company had shut the water from California in Imperial Valley. Only a few years ago the United States and Canada came to an agreement over the respective quantities to be diverted at Niagara Falls.

While agreeing with the author on the desirability of definite laws, uniform if possible, respecting water rights, there are some suggestions in the paper which seem wrong.

A National Board, if formed, should certainly have its jurisdiction limited to strictly interstate waters. The difficulty of getting action by any Bureau in Washington hardly warrants the establishment of a new one.

The attitude of the Government officers in connection with water-power control in California is an absolute blockade. They do not allow others to develop it, nor can they develop it themselves. Thus far, conservation has conserved nothing. To have the laws changed so that the Government would develop and supply power at cost would probably be as fatal as the Reclamation Service. In spite of its magnificent publicity department, the Reclamation Service has reclaimed very little in proportion to its expenditure, and only a small portion of that is at such a price that the farmer can afford to pay the rates.

If the Government would grant permits for power development, considering the companies as public service corporations, and regulate

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them as completely as they regulate the railroads, the farmer would get his power much cheaper than under Government ownership.

There is a crying need for something definite in water-right law. The experts cannot tell what the law is, and the Court decisions are very contradictory. The engineers of California will all be glad of something that is determinable. The State Commission seems to have made progress in Oregon. Perhaps others will elsewhere. We should welcome an interstate commission if its jurisdiction covered only strictly interstate questions; but, please deliver us from any more Government Bureaus. Those we come in contact with are pernicious.

Mr. Moore.

W. E. Moore, M. Am. Soc. C. E. (by letter).—Mr. Lewis has contributed a most valuable paper. The need of legislation along these lines has been felt for several years in all the Western States, and will be felt sooner or later in every State in the Union. It is not any exaggeration to state that there is not a single country on the globe which has a water law in accordance with present-day needs.

Oregon certainly has the best law governing water rights of which the writer has any knowledge. It is a long step in the right direction. With its general outline he agrees most heartily, but thinks it does not go far enough—does not cover as much ground as it should. In some respects it should be more specific, for example, in defining the duties of the engineer in granting a right on a stream before he becomes thoroughly familiar with that stream. It requires several years to learn all the characteristics of any stream, and the writer is opposed to any one granting a water right unless the water is there to fulfill the grant. It is true that, in case of a shortage, the Oregon law shuts off the latest appropriators, but these appropriators ought to know whether they will get water for a part of every year, and what part. As every one knows, the low-water flow of every stream varies from year to year, and such data should be available in the office of every State Engineer in order that the water users of that stream will know on what to depend.

There is a growing belief that every State law should limit the water in every case to the least quantity necessary. This is desirable for various reasons; it admits of a wider use of the waters, and, consequently, more water users, and it tends to prevent waste which sooner or later becomes a menace to the public health.

In the writer's opinion, every water contract should be submitted to the State Engineer for approval. In this way many of the contentions between unscrupulous promoters and *bona fide* water users will be avoided. He would also make all plans for the construction of hydraulic works subject to the approval of the State Engineer. There has been a great deal of speculating on water rights granted by State Engineers in several of the Western States, when in reality

Mr. Moore. the grants amounted to nothing. The time has come when such a thing should be impossible. When the State Engineer grants a water right for any purpose, investing capital should be able to rest assured that the water is there, and that the system or plant by which it is to be used will be constructed along right lines. This is just as essential for the water user as it is for investing capital, for it is the water user who ultimately pays the bills, and the better he is protected in his rights, the better will it be for the lasting prosperity of the community.

That Federal legislation is needed on interstate streams is certainly patent to every one. The problem cannot be handled equitably by the different States until the nature of the human race is radically changed. These waters can be apportioned properly between the interested States by the National Government, and that certainly ought to be done without delay, as the problem becomes more complicated from year to year and retards progress very materially.

The writer certainly does not agree with Mr. Lewis in advocating the construction and operation of power-plants by either the Federal or State Governments, unless such work can be entirely and absolutely eliminated from politics.

One of the most valuable features in the operation of the Oregon law is shown by the fact that during the three years it has been in force, it has clearly demonstrated that practically all the contentions over water rights can be satisfactorily settled outside of the Courts. Even the legal profession admits that legal practice has become entirely too complicated and cumbersome, thereby causing injurious and frequently fatal delay. It is obvious, therefore, that anything that will hasten the settlement of contentions and lessen their cost will be a benefit to the community. The writer has no desire to deprive the legal profession of anything that rightfully belongs to it, but it is just as reasonable to contend that the engineer could settle legal questions as it is to argue that the lawyer could settle engineering questions. It is a fact that many engineering questions are intimately connected with legal questions and cannot be separated from them, but as far as possible they should be kept apart. To the writer's mind this is one of the most important problems with which the Engineering Profession has to deal at the present time, and he feels very grateful to Oregon for the many valuable lessons it has given us.

Mr. Bien. MORRIS BIEN, ESQ.* (by letter).—This paper is very valuable in summarizing the present situation regarding water rights in the Western States, and will enable both engineers and lawyers to grasp more fully the great importance of the problems which are yet to be solved in regard to the determination of rights to the use of water.

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* Supervising Engineer, United States Reclamation Service.

Mr. Bien.

In a country where most of the land is practically valueless unless it can receive a water supply for irrigation, it seems strange that it should take so long to provide for a satisfactory and conclusive record of water titles comparable with the record of land titles. The first step in this direction was taken by the State of Wyoming in 1890, and some of the other arid land States have followed along the general lines adopted there.

Large investments, running well into the millions, in connection with irrigation and water-power construction in the arid regions, depend fully as much on the title to the use of water required as on the title to the land whereon the structures are built.

Many enterprises of considerable importance have found themselves compelled to defend in the Courts their right to the use of water essential to the enterprise, the usual examination of the record in such cases giving practically no indication regarding the true condition of the water supply.

So long as it is possible in a number of the arid States for any one to place on record a claim to a quantity of water to be diverted from a particular stream far in excess of its flood flow, and entirely regardless of the fact that all or a large part of the available water supply may have been put to beneficial use, just so long will diastrous failures of water supply be encountered.

Even the Courts of some of the Western States have so far placed faith in such records as to issue decrees declaring water rights vested in litigants which could call for a water supply of many times the greatest known discharge.

The modern system of water law designates the State Engineer as an expert witness to determine all the features necessary for fixing the extent of the vested water rights and the quantity of unappropriated water which may be available for future enterprises. His findings are conclusive, if not appealed to the Courts, and, when thus appealed, his expert determination of the essential facts would not be disturbed except on proof of error.

This is radically different from the bewildering and contradictory statements by ill-qualified witnesses regarding flow of water, capacity of ditches, areas irrigated, etc., which even now are characteristic of litigation regarding water rights in a number of the Western States.

The system which is now being worked out in Oregon and in some of the other Western States will ultimately provide a record of titles to the use of water as reliable within the necessary limitations as our records of title to land under the most up-to-date systems, substantially equivalent to the Torrens system of land title records. The right to the use of water differs from a fee simple title to land in two essential particulars: first, there is no ownership of the *corpus* of the water as there is of the land, the right in the former case is only a right of

Mr. Bien. use; second, the water of the streams is not fixed, but transitory, and, moreover, the quantity available fluctuates from day to day and year to year. Nevertheless, it is possible to provide for an adjustment of the respective rights to the use of the water, and to make such rights as easily determinable as the ownership of land.

The questions of transfer of the place of use and changes in the method of diversion are of extreme difficulty, and before transfer or changes are permitted without loss of priority careful expert investigation is essential.

In one case a considerable area of land bordering on a small stream with the appurtenant water rights was purchased and the place of use and method of diversion were radically changed. Instead of small ditches diverting the water short distances from the stream and after irrigation allowing return seepage to the stream, the entire quantity of water thus claimed was diverted in an iron pipe and carried to another water-shed. It is claimed by water users below this point of diversion that they have suffered a serious diminution in the quantity of water which had formerly been used on the land above and returned to the stream to become available for their use. They claim that the purchaser of the upper lands could not take a large proportion of the water out of the drainage area without seriously impairing their rights. It will doubtless require a decision of the Courts to settle this question.

The determination of water rights on interstate streams is one which, at an early date, should receive the attention of the Federal and State Governments. The plan suggested by Mr. Lewis is undoubtedly the only logical solution of the problem, and these two Governments must co-operate in working out its details.

The principle that water rights on interstate streams must be adjudicated independently of State lines, while indicated in a general way by the decisions of the United States Supreme Court, is not wholly settled.

In the case of Kansas *v.* Colorado, the Supreme Court took the first step, but without definitely announcing such a principle. In the case of Bean *v.* Morris (221 U. S., 485), the Supreme Court assumed that the States would recognize prior vested rights in another State affecting a stream common to both States.

The question, however, is not decided definitely by these cases, and it may be that the United States Supreme Court will lay down this rule definitely in the case recently begun in that Court by the State of Wyoming against the State of Colorado which seems to rest almost wholly on this question.

Mr. Sheley. HORACE W. SHELEY, ASSOC. M. AM. SOC. C. E. (by letter).—For the sake of clearness, the writer has divided his discussion of this timely paper into five parts. Although he has made special mention

Mr. Sheley.

of irrigation rights, he believes, with Mr. Lewis, that the same principles can be applied to the use of water for other purposes.

1.—Measurement of Water.—Before it will be possible to make water rights definite, certain modifications in the units of measurement must be made. Most of the Western States have already abandoned the variable "miner's inch" for the cubic foot of water per second, commonly called the second-foot, but this is a rate of flow and not a quantity; this term conveys no more meaning than the answer "sixty miles an hour" would give to a question about the distance by railroad between two cities. So far as the writer knows, Nevada is the only State which has named a quantity of water, instead of a rate, when fixing water rights. In that State the unit of measure is the acre-foot. Some other States mention the acre-foot in the regulations of their State Engineer's Offices, but do not give it in their statutes.

A further step remains, namely, to fix the maximum rate at which a given quantity of water may be taken; this corresponds to the "peak load" of electrical engineers.

2.—Place of Measurement.—For new irrigation enterprises it is generally better to name some point near the place of use as the point of measurement, in retailing water, because then the wholesaler, or constructor of the irrigation works, cannot be accused of not having properly constructed his reservoirs and canals so as to prevent seepage and waste in transit. If this method had been followed by a certain large company in one of the arid States, it would not now be in legal difficulties over the failure of the floor of a reservoir to hold water, because it could deliver the requisite quantity from another reservoir.

Measurement at the place of use makes it possible for a later comer to improve the ditch of the old appropriator, and take the water formerly wasted in transit for use on his own land. It is an incentive to the older appropriator to make these betterments himself, lest some one else do it and take this water from him.

3.—Changes in Place or Manner of Use.—Because of his experience, both in Utah, where changes in the place and manner of use are permissible, and in adjoining States, where the water is appurtenant to the land, the writer believes that the Utah policy is the better, leading to higher duties and more economical use of the water.

If a farmer has more water than he needs for a given tract, as a result of an excessive appropriation in the beginning, of a change in crops, of more thorough cultivation, or of a rise in ground-water, he will continue to use all the water if he cannot transfer all or part of it to other land without loss of priority. If the law permits the transfer under proper safeguards to others, it leads to greater duty for the water.

Mr. Sheley.

On the other hand, if the water is appurtenant to the land, so that the owner cannot transfer any part of it, it will be necessary for any one desiring to use it to go to the Courts or to a special tribunal, in order to do so, and the difficult burden of proving that the present owner is not applying the water to the best advantage will be on the new comer.

It is sometimes desirable *pro bono publico* to change the manner of use. The laws of Wyoming recognize that some uses are more important than others, and state the preferences, as follows:

> "First—Water for drinking purposes for both man and beast. Second—Water for municipal purposes. Third—Water for the use of steam engines and for general railway use. Fourth—Water for culinary, laundry, bathing, refrigerating (including the manufacture of ice), and for steam and hot-water heating plants. The use of water for irrigation shall be superior and preferred to any use where turbines or impulse water-wheels are installed for power purposes."

4.—Adjudication of Water Rights.—In 1908 the writer assisted the Hon. Caleb Tanner, State Engineer of Utah, in the tabulation of the statements of 1 200 or 1 300 claimants of water rights in the Weber River water-shed, and since then he has had small respect for the truthfulness and reliability of the claims of owners of water rights. Most of the claims were exorbitant. Our Courts have not been averse to granting absurd claims, and in one instance a judge decreed more than 14 ft. depth as the necessary quantity for a tract of land, where 3 ft. would have been ample.

The system of adjudication in Utah has failed completely, thus far, through lack of money to complete the adjudications and the inherent defects in the method used there. The surveys for the adjudication of the Weber River system were started in 1903 or 1904, but the matter has not even reached the District Courts.

The writer believes that the system first used in Wyoming and later modified and used in Oregon, is the only one that is practical.

5.—Interstate Rights.—The position taken by Mr. Morris Bien in the quotation given by Mr. Lewis, to the effect that the States have not now, and never have had, a right to control the waters within their boundaries, seems to be extraordinary, in view of the fact that the United States Government permitted the Territorial Legislatures to make water laws, and it has applied to the States for water rights, as if it were a private corporation, when undertaking irrigation enterprises under the Reclamation Act. Possibly the context of Mr. Bien's statements would explain the paragraph quoted.

All who have had any experience with the red tape and delays at Washington will hesitate about surrendering any State rights to it, unless absolutely necessary.

In conclusion, the writer agrees with others who are studying water laws and the use of water, believing that the principles of preferential use, beneficial use, and priority can and will ultimately be adopted in the determination of rights both in one State and between States. Mr. Sheley.

Mr. Knowles. **Morris Knowles, M. Am. Soc. C. E.**—The speaker is particularly grateful to the author for his clear exposition of the doctrine of appropriation as practiced in Oregon; and is personally interested in the discussion of this important question, as he has the honor of being President of an Association, one important object of which is the improvement and rationalization of the water laws of Pennsylvania. The paramount importance, at this time, of flood prevention and protection, power development, water supply, improvement of navigable rivers, and the whole broad subject of water conservation in every part of the Union, points to the necessity of adopting in every State a well-considered, comprehensive plan, based on adequate State and National legislation.

The speaker agrees most heartily with the suggestion that the Engineering Profession generally, and engineering societies particularly, not only can, but ought to lead in the discussion of every phase of the subject, and lend their aid to the framing of legislation on such a matter, for the consideration of which their members are peculiarly fitted, in many respects better than any other class of citizens. It is time we were putting into action in this field the policy urged by President Ockerson at the Seattle Convention.

Prior Appropriation vs. Riparian Law.—On one point, however, the speaker holds an opposite opinion from the author, which illustrates the peculiar situations that may arise when engineers undertake the discussion of the intricacies of the law.

The case of Kansas *v.* Colorado did not, in the speaker's opinion, declare that "the doctrine of riparian rights, * * * is not the law, and therefore never has been the law," even of interstate waters. On the contrary, Kansas *v.* Colorado definitely followed the principles of riparian rights, as between Kansas and Colorado. The fact that the Colorado use in question was on non-riparian lands did not affect the issue. The Court considered the decision from the point of view of the rights of Kansas as a State against those of Colorado as a State, and not of the rights of individual riparian proprietors in Colorado. These individual rights come under the rule previously enunciated in Anderson *v.* Bassman (140 Fed., 22) and later affirmed by the Supreme Court in Rickey, etc., Co. *v.* Miller (218 U. S., 258) that the riparian owner deduces his rights from the law of his own State and that the private right is "not in his own right, but by reason of and subordinate to the rights of his State" (Turley *v.* Farman, 114 Pac., 278). In the case of Rickey, etc., Co. *v.* Miller, which involved the rights of riparian owners in California and appropriators in Nevada, the rule followed was that

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"the enforcement of either right beyond the boundary of its State must depend upon the concurrence of the other State. Unless the upper State (California) will voluntarily impose conditions upon its citizens in favor of users in the lower State (Nevada) the latter have no right in the matter other than to complain that the lower State as such (and not merely the plaintiff) is not receiving an equitable share of the benefit of the stream."*

The language of the Court in Kansas *v.* Colorado makes plain that the principle of equal rights, which is the basis of riparian rights, was followed. For example, referring to the law in Kansas, which is the law of riparian rights, Justice Brewer said:

"As Kansas thus recognizes the right of appropriating the water of a stream for the purpose of irrigation, subject to the condition of an equitable division between the riparian proprietors, she can not complain if the same rule is administered as between herself and a sister State."

(The use of the word "appropriating" here appears to the speaker to be somewhat unfortunate, but need cause no confusion, for it bears no connection whatever with the doctrine of "appropriation" as practiced in other Western States. Apparently, the word "diverting" would have expressed the idea of the learned judge without danger of confusion.) And again, referring to the statement quoted by the author, from the conclusion of the Court, in the Kansas *v.* Colorado case,

"* * * it is obvious that if the depletion of the waters of the rivers by Colorado continues to increase, there will come a time when Kansas may justly say that there is no longer an equitable division of benefits, and may rightfully call for relief against the action of Colorado."

No support is given by this language to the theory that there may exist here any exclusive right by priority. This is the language of the riparian rights doctrine.

Then, since the premise is in error, the conclusions that "riparian rights are not considered as vested rights by the Supreme Court," and that "if Congress should decide that the enforcement of the doctrine of priority of appropriation and beneficial use, * * * should constitute an equitable apportionment of benefits, it is conceivable that the Supreme Court would uphold such act," must fall. In the speaker's opinion, such an act, in the light of the present generally accepted views of the powers of Congress, would be unconstitutional, both as outside the enumerated powers of the Federal Government, and as an invasion of the right of private property. In fact, the Kansas *v.* Colorado decision says:

"It [each State] may determine for itself whether the common law rule in respect to riparian rights, or that doctrine which obtains in the arid regions of the West of the appropriation of water for the purposes of irrigation shall control. Congress cannot enforce either rule upon any State."

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* Wiel, "Water Rights in the Western States," 3d ed., p. 364.

Mr. Knowles.

We of the East and the country at large must look to other measures than the adoption of the law of appropriation in its entirety for the development and conservation of our water resources.

Executive Board vs. Court Administration.—On the other hand, the speaker agrees with the author in believing that water laws may be better administered by executive boards than by the Courts and by injunction; and he believes that it might be not only lawful, but very serviceable, for Congress to provide the machinery for administering the law with respect to interstate waters, provided the law can be said to be already determined by Court decision. This, however, does not give ground for the broad assertion that "Congress must have power to prescribe by law what shall constitute an equitable division of benefits as to interstate waters." In fact, as already stated, it would seem plain from Kansas *v.* Colorado that Congress does not have that power—a very different one from the power to provide the machinery for administering the law after the decisions of the Supreme Court have prescribed what shall constitute an equitable division of benefits.

This does not in any sense mean that the speaker does not believe that the Federal Government, under the Constitution, can co-operate with the States in exercising its control over the navigability of streams, and their tributaries also, in such a way as to secure great collateral benefits. On the contrary, he holds that opinion most strongly, and believes in the propriety of the adoption by Congress of the Newlands River Regulation Bill and similar measures.

There may be a question, also, as to whether the law has become sufficiently determined to justify the creation of an administrative commission. The doctrine in Kansas *v.* Colorado was clearly stated; but whether this would apply under all conditions is rendered somewhat doubtful by the following from the decision in Rickey, etc., Co. *v.* Miller (218 U. S., 258, 261).

"It is conceivable, to be sure, that the decisions of this Court may determine that the States have rights as against each other *in invitum* in streams that flow through the land of both. (Kansas *v.* Colorado, 206 U. S., 46, 84; Mo. *v.* Ill., 200 U. S., 496, 519, 520.) The rights may vary according to the system of law required by natural conditions. They may be more or less analogous to common law rights between upper and lower proprietors, where irrigation is not necessary, as in most of the older States. (See N. Y. *v.* Pine, 185 U. S., 93, 96.) There may be some, perhaps limited, right of appropriation in the upper State, at least in the water-shed of the stream, where irrigation is the condition of using the land. (See Kas. *v.* Col., 206 U. S., 46, 100-104, 117.) But whatever this Court may decide, if a private owner should derive advantage from such a decision, it would not be in his own right, but by reason of and subordinate to the rights of his State. * * *"

If it be true that the law for all cases has not been determined, it would appear almost certain that any important contest between States

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before an administrative board would be appealed to the Supreme Court, until the universal law had become established, and a Commission might therefore be of no value at present. In addition, it is debatable whether enough important contests between States will arise to require the continuous service of a Commission.

State Commission Administration.—None of these objections applies, however, to administration of intra-state water laws, on a basis of equitable apportionment, by State Commissions. States undoubtedly have power to determine by law what shall constitute an equitable apportionment of the use of water within their borders; and the delegation of this power to a commission cannot be opposed on the ground that it must be exercised only by direct action of the Legislature, any more than the regulation of public utilities by Commission, now so firmly established, can be so attacked. The words of Justice Timilin in Minneapolis, etc., Railway Co. *v.* Wisconsin Railroad Commission, are applicable:

> "It is argued that the power to fix rates is a legislative one and can never be anything else; * * * that the legislative power is by the Constitution vested in the Senate and Assembly, and cannot be set apart except as expressly provided for in the Constitution; but when we add to this that, because of the multitude of detail, the intricacy of the subject, the expert knowledge required, the numerous separate investigations of inter-related questions of fact which are necessary * * * a legislative body * * * would find it an actual rather than a legal impossibility to fix just and reasonable rates, it becomes apparent that this position tends to the conclusion that the State * * * was shorn of some of its usual and necessary power of sovereignty and became impotent to exercise the power of regulation. Regulation by direct action of the legislature has been tried and found impracticable and its attempt generally abandoned."

The speaker has not yet attempted to work out the details of such an administrative riparian system, but believes that it may be possible, by making simple and rapid the determination of riparian rights and of the terms of an equitable division by a suitably constituted commission, and by making proper provision for the condemnation of such rights for public uses under the supervision of such a board, to develop a system which will lead to a full utilization of the waters of a State, with ample protection both to the public and the investor, and with a possibility of obtaining in some instances great collateral public benefits in the way of flood protection, development of water power, improvement of navigation, improvement of quality of water, etc.

The feasibility of such a scheme appealed to Wiel, who says:*

> "This system of law would seem to offer a field for administrative legislation; in fact, a readier field than the law of prior appropriation. Where the test is what is reasonable in each case, discretion must necessarily come into play, whereas where parties have exclusive rights

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* "Water Rights in the Western States," 3d ed., p. 830.

measured by priority there is * * * little room for the exercise of discretion by administrative officers * * *. Where the common law applies the test of reasonableness, legislation is apt and readily applied; as, for example, in dealing with public service companies. The common law says their rates and regulations must be 'reasonable,' and accordingly public service commissions and similar bodies are created. Likewise under the new law of percolating water 'reasonable use' has become the test, and statutory regulation based thereon is being adopted. As yet, however, there has been no attempt to provide a statutory system governing the reasonable use of water by riparian proprietors among themselves, in jurisdictions applying that system, though there would seem a clear field for such legislation if desired." Mr. Knowles.

Limit of Appropriation by Reasonable Use.—The speaker would like to call attention also to the unmistakable tendency (illustrated by the "Pro-rating" statute of Washington, the constitutional limitation of the right to appropriate in Idaho, and such decisions as Basey *v.* Gallagher, 87 U. S., 670; Union Mining Co. *v.* Dangberg, 81 Fed., 73; Anderson *v.* Bassman, 140 Fed., 14; and Schodde *v.* Twin Falls L. & W. Co., 161 Fed., 43) to depart from the strict law of prior appropriation, and to limit appropriation by a requirement of reasonableness, which is doing much to narrow the gulf between the doctrines of appropriation and riparian rights. It appears to him that, as density of population increases in the Far West, this tendency will increase; and that uniformity in the administration of State laws will be approached, in spite of differences in form, by the application of the "rule of reason" to both systems of law, rather than by the abandonment of either one in favor of the other.

On this phase of the subject, Mr. Morris Bien, Supervising Engineer of the U. S. Reclamation Service, speaking before the National Irrigation Congress at Spokane, in 1909, said:

"The doctrine of rights by prior appropriation has been adopted in nearly all the States where irrigation is required; but this doctrine as now generally understood will necessarily require modification. * * *

"In the Yale Law Journal for January, 1909, is a discussion of the idea of reasonable use, whether under the doctrine of riparian rights or the doctrine of appropriation. It shows that the courts have frequently called attention to the fact that the doctrine of appropriation must be modified by the idea of reasonable use which is also a fundamental limitation of the riparian doctrine. This idea of reasonable use will undoubtedly become an important factor in future years when valuable interests depending upon the entire water supply have grown up within many of the irrigation districts, and it becomes necessary to protect these interests in cases of temporary deficiencies which sometimes continue for a number of years in succession. * * * The qualification of the doctrine of prior appropriation by the idea of reasonable use, and the application of the same idea to the riparian doctrine will undoubtedly bring these opposing doctrines much closer together in

Mr. Knowles. actual practice, and is likely in the end to cause a practical uniformity in the governing principles of all the irrigation States."

Best Development of Water Resources.—In conclusion, the speaker wishes to raise the question whether the "Water Power Policy" advocated by the author is necessary to attain the desired ends. If so, the speaker would agree that "the States, in co-operation with the United States," should "develop this power and supply at cost plus interest." But, if it is possible to attain the same ends in other ways and without the tedious delays that must precede such a consummation, the speaker does not see the necessity of adding further commercial enterprises to the burdens of our State Governments. In the belief that, under a rational, well-defined system of water laws, and with wise State regulation in the interest of the people, private capital would construct the works necessary to the conservation of water, the Pennsylvania Water Conservation Association has been formed. This Association, including in its membership capitalists, publicists, civic bodies, power companies, and water companies, has for its object the formulation of a plan for the development and utilization of the water resources of the State, by means of private capital, under improved laws and State supervision, in such a way as to offer a safe, attractive field for investment; to insure reasonableness of rates and safety of construction; to secure, wherever possible, by supervision of designs and operation, prevention of floods and improvement of rivers; and to serve by a broad, far-sighted policy of conservation the public interests of this and of future generations.

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PAPERS AND DISCUSSIONS

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A SHORTENED METHOD IN ARCH COMPUTATION.

Discussion.*

By William Cain, M. Am. Soc. C. E.

Mr. Cain.

William Cain, M. Am. Soc. C. E. (by letter).—The author has made a successful attempt to shorten certain calculations pertaining to the theory of the arch without hinges, where single loads are considered. As the number of parts into which the arch ring is divided is increased, the burden of computation is very much increased, and any device for shortening the work will be appreciated by the computer.

As the subject is of such practical importance, the writer will give a method of computing the quantities in question by a brief and independent procedure, and will incidentally derive check formulas for the difference method proposed by the author.

In the diagram, Fig. 2, the horizontal distances of the loads, P_1, P_2, . . . , from the center of the span, A, will be denoted by d_1, d_2, ...

From any P, as P_2, are drawn the two sides of the trial equilibrium polygon pertaining to this load, the one to the right of the load, $P_2\,A$, being horizontal, the one to the left, $P_2\,B_2$, being inclined at an angle of 45° to the horizontal. It follows that $b_4\,h_4 = h_4\,P_4$, $b_4\,h_3 = h_3\,P_4$, etc.; whence, for the lines, $P_4\,B_4$, $P_3\,B_3$, we have,

$$\begin{aligned} b_4\,h_4 &= z_4 - d_4\,, \\ b_4\,h_3 &= z_3 - d_4 \\ b_4\,h_2 &= z_2 - d_4 \\ b_4\,h_1 &= z_1 - d_4 \\ \hline \sum_o^4 b_4\,h &= \sum_o^4 (z) - 4\,d_4, \end{aligned} \qquad \begin{aligned} b_3\,h_3 &= z_3 - d_3 \\ b_3\,h_2 &= z_2 - d_3 \\ b_3\,h_1 &= z_1 - d_3\,, \\ \hline \sum_o^3 b_3\,h &= \sum_o^3 (z) - 3\,d_3. \end{aligned}$$

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* This discussion (of the paper by H. A. Sewell, Esq., published in October, 1912, *Proceedings*, but not presented at any meeting), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Cain.

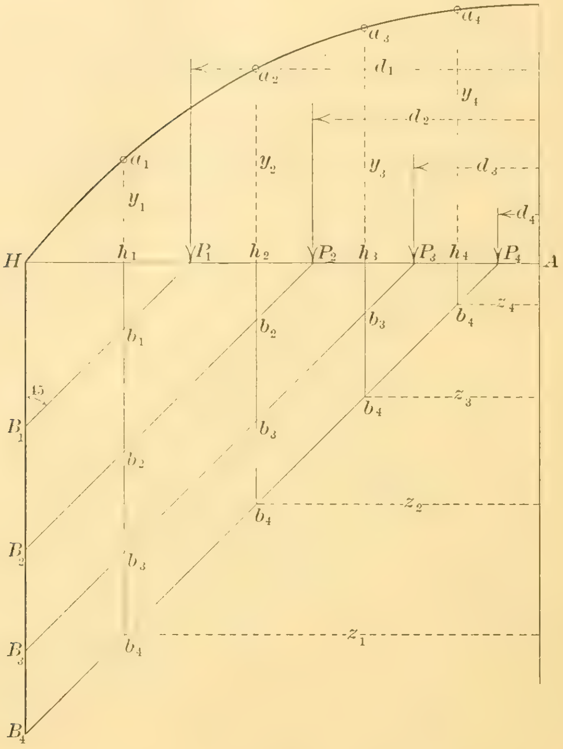

FIG. 2.

Or, more generally, dropping the b subscripts, the sums can be indicated thus:

$$\sum_{o}^{n}(bh) = \sum_{o}^{n}(z) - n\,d_n \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Thus, for $n = 4$, referring to the load, P_4, and the side of its equilibrium polygon, $P_4\,B_4$,

$$\sum_{o}^{4}(bh) = b_4\,h_4 + b_4\,h_3 + b_4\,h_2 + b_4\,h_1; \quad \sum_{o}^{4}(z) = z_1 + z_2 + z_3 + z_4.$$

This formula enables us to compute directly $\sum_{o}^{n}(bh)$ corresponding to $P_n\,B_n$ for any P_n, or for $n = 1, 2, 3, \ldots$ in turn.

Now let,

$$\sum_{o}^{n}(bh.z) = bh_1.z_1 + bh_2.z_2 + bh_3.z_3 + \ldots + bh_n.z_n.$$

Mr. Cain.

Thus, if $n = 4$, the bh's refer to the line $P_4\ B_4$. It follows, from the relations given above, that,

$$\sum_o^n (bh.z) = (z_1 - d_n)\, z_1 + (z_2 - d_n)\, z_2 + \cdot\ \cdot\ \cdot + (z_n - d_n)\, z_n$$

$$= (z_1^2 + z_2^2 + \cdot\ \cdot\ \cdot + z_n^2) - d_n\,(z_1 + z_2 + \cdot\ \cdot\ \cdot + z_n)$$

or,

$$\sum_o^n (bh.z) = \sum_o^n (z^2) - d_n \sum_o^n (z) \quad \dots\dots\dots\dots (2)$$

in which the notation is sufficiently explained by the equivalent expansions above. Similarly, if,

$$\sum_o^n (bh.y) = bh_1.y_1 + bh_2.y_2 + \cdot\ \cdot\ \cdot + bh_n.y_n,$$

indicates the sum of quantities of the type $(bh.y)$ for any line $P_n\ B_n$ corresponding to a load, P_n, we have,

$$\sum_o^n (bh.y) = (z_1 - d_n)\, y_1 + (z_2 - d_n)\, y_2 + \cdot\ \cdot\ \cdot + (z_n - d_n)\, y_n$$

$$= (z_1\, y_1 + z_2\, y_2 + \cdot\ \cdot\ \cdot + z_n\, y_n) - d_n\,(y_1 + y_2 + \cdot\ \cdot\ \cdot + y_n)$$

which can be indicated by the shorter notation,

$$\sum_o^n (bh.y) = \sum_o^n (z\, y) - d_n \sum_o^n (y) \quad \dots\dots\dots\dots (3)$$

Thus the sums desired, for P_n and its corresponding $P_n\ B_n$, can be computed directly from Formulas (1), (2), and (3), on giving the proper numerical value to n.

Before giving a numerical application of the formulas, it may be well to derive the author's difference formulas from them.

Thus, if in Formula (1), we change n to $(n - 1)$ and subtract, we find,

$$\sum_o^n (bh) - \sum_o^{n-1} (bh) = z_n - n d_n + (n - 1)\, d_{n-1}$$

$$= (n - 1)\,(d_{n-1} - d_n) + (z_n - d_n) \quad \dots\dots (4)$$

This formula can also be obtained directly from the figure. Thus, take $n = 4$, $n - 1 = 3$, then the left number of Formula (4) equals $3\ (b_4\ b_3) + b_4\ h_4$, which reduces to $3\ (d_3 - d_4) + (z_4 - d_4)$, or to the right member.

Similarly, in Formula (2), change n to $(n - 1)$ and subtract. Therefore,

$$\sum_o^n (bh.z) - \sum_o^{n-1} (bh.z) = z_n^2 + d_{n-1} \sum_o^{n-1} (z) - d_n \sum_o^n (z)$$

$$= z_n^2 + d_{n-1} \sum_o^{n-1} (z) - d_n \left(\sum_o^{n-1} (z) + z_n \right)$$

$$= (d_{n-1} - d_n) \sum_o^{n-1} (z) + (z_n - d_n)\, z_n \quad \dots\dots\dots\dots (5)$$

Mr. Cain. A similar procedure, using Formula (3), gives,

$$\sum_{o}^{n} (bh.y) - \sum_{o}^{n-1} (bh.y) = z_n \, y_n - d_n \sum_{o}^{n} (y) + d_{n-1} \sum_{o}^{n-1}$$

$$= (d_{n-1} - d_n) \sum_{o}^{n-1} (y) + (z_n - d_n) \, y_n \cdots\cdots\cdots \quad (6)$$

Formulas (5) and (6) can likewise be derived directly from the figure by developing the left members and reducing. It will be observed that Formulas (4), (5), and (6), are equivalent to the author's formulas on noting that $d_n = \frac{L}{2} - p_n$.

To illustrate the application of Formulas (1), (2), and (3), take the segmental arch considered in the writer's "Theory of Solid and Braced Elastic Arches,"* where only eight divisions of the semi-arch were made. Of course, in a practical design, a greater number of divisions are essential for fairly accurate results, so that this particular investigation is only intended to illustrate the method for any arch, using any number of dimensions.

The neutral line of the arch is shown in Fig. 3, also the two sides of the equilibrium polygon for each load P_n ($n = 1, 2, 3, \ldots$) are drawn from the computations in the book.

To effect these computations, the sums, $\Sigma\,(bh)$, $\Sigma\,(bh.z)$, $\Sigma\,(bh.y)$, are needed, and these will now be found for each load by aid of the writer's Formulas (1), (2), and (3), which will thus show the great saving in the labor of computation over the method used in the text.

The values of the vertical ordinates, y_1, y_2, . . . ; at the points, a_1, a_2, . . . , the horizontal distances, z_1, z_2, . . . , of these same points from the center of the span, and the horizontal distances, d_1, d_2, . . . , of the unit loads, P_1, P_2, . . . , from the center of the span, were all measured from a large-scale drawing, and their numerical values are all inserted in Tables 2, 3, and 4, together with certain derived sums needed in the application of the formulas. The method of computation is sufficiently indicated in Tables 2 and 3. In Columns 16, 18, and 20, of Table 3 are found $\Sigma\,(bh)$, $\Sigma\,(bh.z)$, $\Sigma\,(bh.y)$, for the trial equilibrium polygons corresponding to each load, P_1, P_2, . . . , P_8 in turn. From these derived quantities, by use of very simple formulas given in the text quoted, the values of the horizontal thrust, the vertical components of the reactions at the springings, and the ordinates of the equilibrium polygons at the loads and at the springings are quickly found for each load, P. The equilibrium polygons are now to be drawn, as shown in Fig. 3, and the arch investigated for the actual live and dead loads.

In Table 4, the quantities, $\Sigma\,(bh)$, $\Sigma\,(bh.z)$, $\Sigma\,(bh.y)$, are computed by the author's method of differences, using Formulas (4), (5), and

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* Chapter V, Second Edition.

Mr. Cain.

(6). Some care must be exercised here to avoid mistake. Thus, suppose the quantities pertaining to P_3 are to be computed. Substitute $n = 3$ in each of the formulas at the tops of the columns and put the results in the same line with P_3. Then add the results in Columns (4) and (5) on the same line with P_3 to the previous $\sum_{o}^{2}(bh) = 6.05$ to get $\sum_{o}^{3}(bh) = 10.46$, as given in Column (6). Similarly, proceed with Columns (8) and (9) to find $\sum_{o}^{3}(bh.z) = 117.01$, as given in Column (10), and with Columns (12) and (13) to find $\sum_{o}^{3}(bh.y) = 40.47$, as given in Column (14).

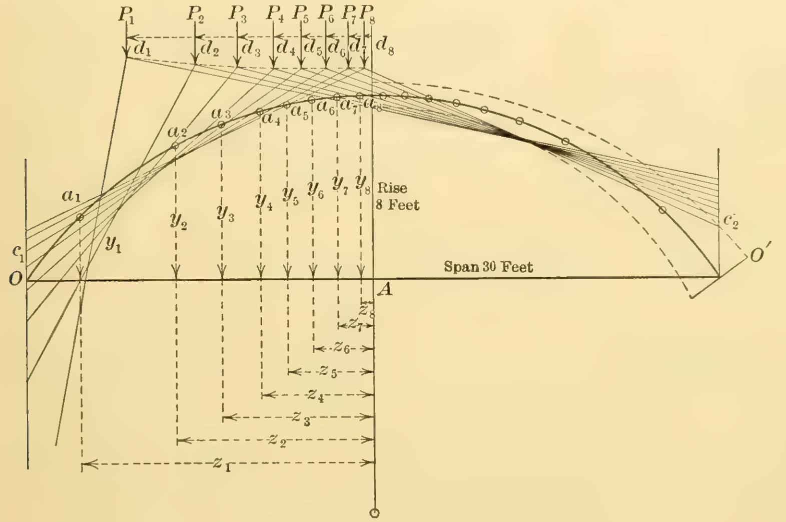

Fig. 3.

With a little care, it is hardly necessary to repeat the numbers added, so that the table can be compressed to about one-third the space here used. As a complete check on the results, the values given for $n = 8$ in Columns (6), (10), and (14), can also be found by use of Formulas (1), (2), and (3), exactly as indicated in Table 3, where n is given the value 8. Further, a check may be given where any value of n, as $n = 4$, is reached, by the use of the same Formulas (1), (2), and (3). The independent method illustrated in Table 3 is somewhat shorter than the difference method, but it can only be checked by repeating the computations. This complete check on the work is the principal gain afforded by the author's method of dif-

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TABLE 2.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
n	Point.	y	$\Sigma_0^n\,(y)$	y^2	z	$\Sigma_0^n\,(z)$	z^2	$\Sigma_0^n\,(z^2)$	$z\,y$	$\Sigma_0^n\,(z\,y)$
1...........	a_1	2.77	2.77	7.67	12.72	12.72	161.80	161.80	35.23	35.23
2...........	a_2	5.74	8.51	32.95	8.73	21.45	76.21	238.01	50.11	85.34
3...........	a_3	6.72	15.23	45.16	6.65	28.10	44.22	282.23	44.69	130.03
4...........	a_4	7.28	22.51	53.00	5.08	33.18	25.81	308.04	36.98	167.01
5...........	a_5	7.60	30.11	57.76	3.79	36.97	14.36	322.40	28.80	195.81
6...........	a_6	7.81	37.92	61.00	2.63	39.60	6.92	329.32	20.54	216.35
7...........	a_7	7.92	45.84	62.73	1.53	41.13	2.34	331.66	12.12	228.47
8...........	a_8	7.99	53.83	63.84	0.51	41.64	0.26	331.92	4.07	232.54
		53.83		384.11	41.64		331.92			

TABLE 3.

(12)	(13)	(14)	(15)	(16) = (7) — (15)	(17)	(18) = (9) — (17)	(19)	(20) = (11) — (19)
n	Load.	d_n	nd_n	$\Sigma_0^n\,(bh) =$ $\Sigma_0^n\,(z) - n\,d_n$	$d_n\ \Sigma_0^n\,(z)$	$\Sigma_0^n\,(bh.z) =$ $\Sigma_0^n\,(z^2) - d_n\ \Sigma_0^n\,(z)$	$d_n\ \Sigma_0^n\,(y)$	$\Sigma_0^n\,(bh.y) =$ $\Sigma_0^n\,(z\,y) - d_n\ \Sigma_0^n\,(y)$
1.......	P_1	10.73	10.73	1.99	136.49	25.31	29.72	5.51
2.......	P_2	7.70	15.40	6.05	165.16	72.85	65.53	19.81
3.......	P_3	5.88	17.64	10.46	165.23	117.00	89.55	40.48
4.......	P_4	4.43	17.72	15.46	146.99	161.05	99.72	67.29
5.......	P_5	3.22	16.10	20.87	119.04	203.36	96.95	98.86
6.......	P_6	2.09	12.54	27.06	82.76	246.56	79.25	137.10
7.......	P_7	1.02	7.14	33.99	41.95	289.71	46.76	181.71
8.......	P_8	0.24	1.92	39.72	9.99	321.93	12.92	219.62

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TABLE 4.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
n	Load.	$d_{n-1}-d_n$	$(n-1)(d_{n-1}-d_n)$	z_n-d_n	$\Sigma_o^n(bh)=$ $\Sigma_o^{n-1}(bh)+(4)+(5)$	$\Sigma_o^{n-1}(z)$	$(d_{n-1}-d_n)\Sigma_o^{n-1}(z)$	$(z_n-d_n)z_n$	$\Sigma_o^n(bh.z)=$ $\Sigma_o^{n-1}(bh.z)+(8)+(9)$	$\Sigma_o^{n-1}(y)$	$(d_{n-1}-d_n)\Sigma^{n-1}(y)$	$(z_n-d_n)y_n$	$\Sigma_o^n(bh.y)=$ $\Sigma_o^{n-1}(bh.y)+(12)+(13)$
1...	P_1		0	1.99	1.99 3.03 1.03	0	0	25.32	25.32 38.54 8.99	0	0	5.51	5.51 8.39 5.91
2...	P_2	3.03	3.03	1.03	6.05 3.64 0.77	12.72	38.54	8.99	72.85 39.04 5.12	2.77	8.39	5.91	19.81 15.49 5.17
3...	P_3	1.82	3.64	0.77	10.46 4.35 0.65	21.45	39.04	5.12	117.01 40.74 3.30	8.51	15.49	5.17	40.47 22.08 4.73
4...	P_4	1.45	4.35	0.65	15.46 4.84 0.57	28.10	40.74	3.30	161.05 40.15 2.16	15.23	22.08	4.73	67.28 27.23 4.33
5...	P_5	1.21	4.84	0.57	20.87 5.65 0.54	33.18	40.15	2.16	203.36 41.77 1.42	22.51	27.23	4.33	98.84 34.01 4.22
6...	P_6	1.13	5.65	0.54	27.06 6.42 0.51	36.97	41.77	1.42	246.55 42.37 0.78	30.11	34.01	4.22	137.07 40.57 4.04
7...	P_7	1.07	6.42	0.51	33.99 5.46 0.27	39.60	42.37	0.78	289.70 32.08 0.14	37.92	40.57	4.04	181.68 35.75 2 16
8...	P_8	0.78	5.46	0.27	39.72	41.13	32.08	0.14	321.92	45.84	35.75	2.16	219.59

Mr. Cain. ferences, and he is to be congratulated on having derived such a brief and valuable method of computation.

In conclusion, a few words may not be inappropriate concerning the advantage of the method of single loads in arch analysis. This consists not only in an increased accuracy, but is the only practicable method by which maximum fiber stresses can be ascertained. Thus, after the equilibrium polygons for the various unit loads have been drawn, the exact position of the live load to give the maximum stress at any section of the arch can be at once determined from the figure. The writer has shown* the great variations in stress at the critical sections of an arch as a live load moves across it, and has indicated probable positions for this load to cause maximum fiber stress at certain sections. Evidently, however, the positions will depend on the shape of the arch, and will thus vary as the arch is thicker or thinner and also with the curves of the intrados and extrados. The method of single loads gives certainty, the usual method uncertainty, in endeavoring to find maximum stresses. It is feared, therefore, that of the tens of thousands of concrete arches built in the United States, the maximum stresses in but very few have been ascertained. The subject is a vital one, and of practical importance.

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* "Theory of Solid and Braced Elastic Arches."

MEMOIRS OF DECEASED MEMBERS

NOTE.—Memoirs will be reproduced in the volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

BENJAMIN MORGAN HARROD, Past-President, Am. Soc. C. E.*

DIED SEPTEMBER 7TH, 1912.

Benjamin Morgan Harrod was born in New Orleans, La., on February 19th, 1837. His father, Charles Harrod, came to that city in 1809, and made it his home. His mother, Mary Morgan, was a native of Louisiana, and the daughter of Benjamin Morgan who had come from Pennsylvania in the late years of the previous century and engaged in business and planting.

After attending the local schools, he prepared for college at Flushing, N. Y. He afterward entered Harvard University and was graduated in the class of 1856, with a well-formed intention of following a technical or constructive profession.

After a year or more of preparatory study, Mr. Harrod secured employment as Draftsman, in the United States Engineer Office in charge of the construction of forts and light-houses on the Gulf Coast, from the Mississippi River to the Rio Grande River, and subsequently was appointed Assistant Engineer. In 1859 he commenced practice in New Orleans, as an Engineer and Architect.

In April, 1861, he enlisted as a private in the Confederate Army, and was soon commissioned as Lieutenant in an Artillery Regiment, being detailed on engineer duty. He served as Brigade and Division Engineer with the command of Gen. M. L. Smith in the fortification and defense of New Orleans and Vicksburg. When exchanged after the surrender of the latter place, he was commissioned as Captain of Engineer troops in Virginia, was engaged in the defense of Petersburg and Richmond, and followed the fate of that Army to the surrender at Appomattox, in 1865. He then resumed professional practice in New Orleans.

In 1877 Major Harrod was appointed Chief State Engineer of Louisiana, with the late H. B. Richardson and T. S. Hardee, Members, Am. Soc. C. E., as associates, on a board, the principal function of which was the construction of a system of levees to protect the alluvial regions of the State from overflow.

In 1879 he was appointed an Engineer member of the Mississippi River Commission, charged by the United States Government with the survey of the Mississippi River and its tributaries, and the improvement of the main streams from the junction of the Ohio to the head of the Passes, with special reference to confinement and its conservative influence on navigation. The importance of this latter part of the work of the Commission was subsequently recognized by the Government, and the repair and building of levees was made mandatory. It has been one of the most beneficent and remunerative works of the age, affecting the reclamation from overflow of 30 000 sq. miles of territory of unsurpassed fertility, and its development in population, agriculture, commerce, and wealth.

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* Memoir prepared by the following committee: Frank M. Kerr, Sidney F. Lewis, and Arsene Perrilliat, Members, Am. Soc. C. E.

From 1888 to 1892 Major Harrod was City Engineer of New Orleans, and, subsequently, Advisory Engineer for the drainage, sewerage, and water-works systems of that city; and from 1897 to 1902, he had charge of the drainage, both designing and constructing.

In 1903 he was appointed, with Gen. C. W. Raymond and John Bogart, Members, Am. Soc. C. E., as the first United States Delegates to the International Congress of Navigation, held that year at Düsseldorf, Germany, but was prevented by business from attending its sessions.

In 1904 he was appointed a Member of the Panama Canal Commission, and served until 1907, when the type of the canal was determined and the charge of the work was transferred to the present Commission. His subsequent work was as a Consulting Engineer in New Orleans.

He married, in 1865, Miss Harriet Shattuck Uhlhorn, and, in 1883, Miss Eugenia Uhlhorn, both of New Orleans, the latter surviving him.

The degree of LL.D. was conferred on him by Tulane University, in 1906, as a

> "Graduate of Harvard University fifty years ago; President of the American Society of Civil Engineers; expert specialist and virile all-round man; friend of Tulane University and of all movements to better this City. In deepening a river and now in cutting an isthmus, his work has ever been to bring men closer in commerce, in friendship, and in mutual helpfulness."

Major Harrod was also a Member of the Association of Harvard Engineers, and its Vice-President in 1909, as well as a Member of the Louisiana Engineering Society.

He was a man of sterling qualities and strong individuality, but at all times generous and kind, and the friend of the worthy young aspirant for advancement in the Profession. Recognized, as he was, as a man of letters, of science, and of pronounced artistic taste, and as a high-toned, patriotic, public-spirited, loyal citizen, his loss will long be felt by the many who in life had the privilege of knowing him and in consequence admiring him.

Major Harrod was elected a Member of the American Society of Civil Engineers on April 4th, 1877. He served as Director from 1892 to 1894, as Vice-President in 1895-96, and as President in 1897.

THOMAS MOORE JACKSON, M. Am. Soc. C. E.*

DIED FEBRUARY 3D, 1912.

Thomas Moore Jackson, son of James Madison and Caroline Moore Jackson, was born at Clarksburg, W. Va., on June 22d, 1852. He received his early education at the public schools and at the Northwest Academy, of Clarksburg, and at Bethany College. He afterward entered Washington and Lee University where he took a special course in civil and constructive engineering, and from which he was graduated in June, 1873, with high honors, with the degree of Civil Engineer.

From 1874 to 1875, Mr. Jackson served as Chief Engineer of the Middle Island Railroad, in West Virginia, and from 1875 to 1879, he was Chief Engineer of the Weston and West Fork Railroad. In 1879, he was appointed First Assistant Engineer of the Iron Valley and Morgantown Railroad, later becoming Chief Engineer.

Mr. Jackson resigned this position to accept that of Chief Engineer of the Tunnelton and Kingwood Railroad, in West Virginia, where he remained until 1881, when he was appointed Engineer in Charge of mines at Wilsonburg, Clarksburg, Flemington, and Gaston, W. Va. Mr. Jackson had been engaged in mining engineering in various parts of West Virginia and Pennsylvania since 1875, and in co-operation with I. C. White, State Geologist, he opened and developed many of the coal, oil, and gas territories in various sections of West Virginia, being one of the pioneers in this field.

In 1882, Mr. Jackson was appointed Chief Engineer of the West Virginia and Pennsylvania Railroad. He held this position until 1885, when he resigned. He was retained, however, by the Company as Consulting Engineer for many years.

In 1887, he was made Assistant Engineer of the Clarksburg Water-Works and was also Engineer in Charge of geological maps of West Virginia and Pennsylvania, working on the coal fields of these States. In 1888, he was engaged in building coke plants at Wilsonburg, Clements, and Clarksburg, W. Va., and, in 1889, he went to Morgantown, W. Va., as Chief Engineer of the water-works and natural gas plant at that place.

In 1889 the Chair of Civil and Mining Engineering was established at the West Virginia State University, and Mr. Jackson was placed at the head of that Department. He remained in this position until 1891, when, the School of Engineering having been firmly established, he resigned against the protests of the Board of Regents and the Faculty of the University, to take up the active practice of his Profession.

After leaving the University, Mr. Jackson served as Chief Engineer of several railroads, among which was the narrow-gauge road from

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* Memoir prepared by the Secretary from papers on file at the Society House.

Clarksburg to Weston, afterward known as the West Virginia and Pittsburg Branch of the Baltimore and Ohio Railroad.

Being prominent in the development of the coal, oil, and gas industries of that section of West Virginia about Clarksburg, and realizing the importance of a more direct route to the Ohio River from the latter place for the transportation of these products, Mr. Jackson undertook and was directly responsible for the building of the West Virginia Short Line Railroad, from Clarksburg to New Martinsville, which was completed and opened to traffic in 1901. He was President of this road until its purchase by the Baltimore and Ohio Railroad.

In 1910, Mr. Jackson organized and was made President of a company to build the Clarksburg and Northern Railroad to extend from New Martinsville, by way of Middlebourne and Salem, to Clarksburg, W. Va. Construction work on this road was begun in 1912, and the grading completed between New Martinsville and Middlebourne. Mr. Jackson had just returned to Clarksburg from New Martinsville, where he had been on business in connection with the new road, when he was seized with a severe attack of heart trouble which caused his death on February 3d, 1912, after a short illness.

In 1884, he was married to Miss Emma Lewis, daughter of Judge and Mrs. C. S. Lewis, who, with one daughter, survives him.

Mr. Jackson was a courteous and cultured gentleman, friendly and companionable on all occasions, who was esteemed and admired by all who knew him. He was one of the most prominent and progressive citizens of Clarksburg and was well known among business and professional men throughout the State. Practically his entire life was spent in his home town, and he did much toward its development as an industrial center. His ability as a civil engineer and his great knowledge of geology enabled him to realize the importance of the vast gas, oil, and coal areas in and around his home section and also the necessity of developing them for the establishment of manufacturing industries. It was through his efforts that the Jackson Iron and Tinplate Mills, now the Phillips Sheet and Iron Mills, which is one of the most valuable industrial plants in West Virginia, was established in Clarksburg.

He was President of the Traders National Bank of Clarksburg until its merger with the People's Banking and Trust Company into the Union National Bank, and was one of the chief promoters of the Traders Hotel, the building of which gave the city an up-to-date hotel.

The degrees of Mining Engineer, Doctor of Science, and Civil Engineer had been conferred on him by Washington and Lee University and by the West Virginia State University, respectively, and, as a member of Governor Fleming's staff, he had received the honorary title of Colonel.

Mr. Jackson was elected a Member of the American Society of Civil Engineers on June 9th, 1891.

WILLIAM FREDERICK LOCKWOOD, M. Am. Soc. C. E.*

DIED AUGUST 22D, 1912.

William Frederick Lockwood was born in New York City on July 4th, 1867, and, after attending the public schools, learned the trade of steam fitter. He entered the Engineering Department of what is now the Suburban Branch of the Third Avenue Elevated Railway during its construction in August, 1888, and on its absorption by the Manhattan Railway Company, in 1891, was taken into the Chief Engineer's Office, serving successively as Draftsman and Assistant Engineer until September 16th, 1900, when he was appointed Road Engineer, the duties of which office were the maintenance of the elevated railway structures.

While working as a Draftsman, Mr. Lockwood realized the limitations of his early education, and attended Cooper Institute in his spare time, receiving the degree of Bachelor of Science in 1894.

He was appointed Engineer of Maintenance of Way of the Interborough Rapid Transit Company on October 1st, 1905. His continuous term of service on the elevated roads covered twenty-four years, or practically his entire working life. During this time the roads were being extended, and improvements were being adopted, thus making the conditions of maintenance very burdensome, on account of the deeper foundations of buildings and numerous sub-surface structures, such as subways, conduit lines, high-pressure water mains, etc., which required the reconstruction of numerous foundations for the railway and the constant shoring of the structure at various points.

The adoption of electric motive power, requiring the reinforcement of the structure, was in itself a great task, and the constantly increasing street traffic rendered all such work more and more difficult. It is easily seen that such conditions would tend to keep a man of Mr. Lockwood's conscientious temperament very busy.

During all this time he had the care of his mother's family as well as his own. Time for study and almost for recreation was practically denied him.

His personality was somewhat unique, in that it was so fine. Of clear intellect, inflexible integrity, tireless industry, great patience, and a charming presence, he was a power for influence and accomplishment.

Mr. Lockwood died after a short illness following an operation for appendicitis. He is survived by his widow and three children, Ruth, Blanche, and Constance, and four sisters.

Mr. Lockwood was elected a Member of the American Society of Civil Engineers on October 4th, 1910.

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* Memoir prepared by George H. Pegram, M. Am. Soc. C. E.

EDWARD MOHUN, M. Am. Soc. C. E.*

DIED OCTOBER 23D, 1912.

Edward Mohun, was born at Chigwell, England, on September 3d, 1838. In 1863, he came to Victoria, B. C., Canada, and during 1863 and 1864 was engaged as Assistant to the Surveyor General.

From 1864 to 1871, he was employed mainly on official surveys: laying out roads, etc., extending from Comox to Sooke, Nicola, South Thompson, and Bonaparte Valleys; surveying the Lower Fraser from Chilliwack to its mouth, Burrard Inlet, Squamish River, etc.; exploring Queen Charlotte Islands south; and making surveys for a waterworks system for Victoria and for the Wellington and Departure Bay Railway.

In 1871 and 1872, Mr. Mohun was engaged as Divisional Engineer on the Eagle Pass and Yellowhead Pass surveys for the Canadian Pacific Railroad. He also drove the first stake and made the first survey for this road on the Pacific Coast. In 1873, he explored the north end of Vancouver Island, and in 1875-76 was engaged in Government Surveys on that island and on the Lower Fraser River.

In 1876, he received the appointment of Surveyor to the Dominion and Provincial Joint Indian Commission, serving as Chief of the Survey from 1877 to 1884.

In 1885 Mr. Mohun was engaged on the reclamation and diking of 7 000 acres on the Lower Fraser River. While on this work he invented the sluice-box which was adopted by the Government and has been in use for more than 15 years, effecting the saving of many thousands of dollars.

In 1886, he made a test of the woods of British Columbia for which he received his proudest possession, a certificate signed "Albert Edward" and a medal. These tests agreed with similar tests made by the United States Government some twenty years later, and are the basis on which all strains in bridges built by the British Columbia Government are supposed to be calculated.

In 1887, Mr. Mohun designed and constructed the first portion of the sewerage system of Vancouver, B. C., the second portion being built under his supervision in 1889 and 1890.

In a competition for the design of a sewerage system for Victoria, B. C., in 1890, he was awarded the premium over eight competitors from Eastern Canada, the United States, and England, and was appointed Chief Engineer on its construction. As a result of the installation of this system, the death rate of Victoria was reduced 25% in three years.

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* Memoir prepared by the Secretary from information on file at the Society House.

From 1893 to 1895, Mr. Mohun was employed as Provincial Government Railway Inspector, and, in 1895, he was appointed Engineer in Charge of the Pitt Meadows Dikes.

In 1898, he made a report to the Government on the sanitary condition of Rossland, Trail, Nelson, Kaslo, Revelstoke, Kamloops, New Westminster, Cumberland, Wellington, and Nanaimo. In the same year he entered the office of the Engineer of Public Works, and, in 1908, was gazetted as First Assistant Engineer. During this time he was engaged in the design of various public works, and since 1896 he had also acted as Consulting Engineer to the Provincial Board of Health, to which, in 1892, he had reported on the "Bacterial Treatment of Sewage." His conclusions on this subject were practically confirmed a few years later by the British Royal Commission on Sewage Disposal.

Mr. Mohun was the author of many engineering papers and of tables which are in constant use on the Pacific Coast. He was a Member of the Canadian Society of Civil Engineers, a Gzowski Medallist, and was also at one time Member of the Council of the Society. He was also a Member of the Royal Sanitary Institute, and for fifteen years was a Justice of the Peace for the Province.

Mr. Mohun was elected a Member of the American Society of Civil Engineers on April 6th, 1892.

WILLIAM MADISON MYERS, Assoc. M. Am. Soc. C. E.*

Died April 4th, 1912.

William Madison Myers, son of William H. and Mary Jane (Harman) Myers, was born near Winchester, Va., on April 4th, 1873. His parents, who lived on a fine farm in the Shenandoah Valley, perceiving that the son had a fondness for books and study, and realizing the value of education, determined to fit him for a professional life. After availing himself of all the advantages of the country schools, Mr. Myers entered the Winchester High School, from which he was graduated in 1891. In the fall of the same year he entered Washington and Lee University, and was graduated from that institution in 1895, with the degree of Civil Engineer.

For some time after his graduation, he taught in the Graded Schools of Frederick County, Virginia, being engaged occasionally on local surveying and engineering work. In 1897 and 1898, he was in charge of road improvements between Leesburg and Harper's Ferry, Va., under Frank Conrad, Civil Engineer.

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* Memoir prepared by Mrs. Bessie B. McCann.

In 1898, Mr. Myers accepted an offer from the late Lewis Kingman, M. Am. Soc. C. E., then Chief Engineer of the Mexican Central Railway, to go to Mexico as Transitman on the location of the Tampico Division of that railway, being also at times in charge of a party locating reservoir sites, etc. In 1900 he was appointed Assistant, under Mr. W. C. Harris, on the construction of the Parral Extension of the same road, and, in 1901 and 1902, he was with Mr. O. G. Bunsen, as Transitman and Topographical Draftsman, on the location of the Colima Extension.

From 1902 to 1904, Mr. Myers was employed as Division Engineer on the construction of the San Pedro Extension of the Mexican Central Railway, and, while in this position, had charge of the construction of 50 km. of the road, as well as of all the Division yards and buildings. He remained in this position until the work was completed, when he returned to Virginia to visit his old home. After seven years' service on the Mexican Central Railway, under Mr. Kingman, the latter wrote of him:

"Mr. Myers is a gentleman and an educated engineer, and has done all his work, while under my jurisdiction, with credit to himself and to the entire satisfaction of the Railway Company. I take pleasure in recommending Mr. Myers. He is honest, truthful, and considerate. He is industrious, temperate, and careful in his work. He understands the classification of material, and has always done the right thing with the contractors and the Railway Company."

In 1904, Mr. Myers was appointed Transitman and Topographical Draftsman on the Florida East Coast Railway, but in less than a year, because of the climatic conditions, was compelled to resign this position and return to his home to recuperate.

In 1905, he went back to Mexico, as Division Engineer, under Mr. Kingman, on the construction of the Colima Extension of the Mexican Central Railway from Tuxpan to Colima. This work was very heavy and included the construction of three tunnels in a distance of 7 km. In 1906, Mr. Myers accepted a position with Pierson and Sons, of the Puebla Tramway, Light and Power Company, at Puebla, Mexico, his work consisting of city surveys, and surveys and estimates for water-works, hydro-electric plants, electric lines, etc. Of him and his work at this place, Mr. Pierson has written:

"I consider him an able and experienced railway and general engineer, competent to take charge of important work. * * * As to Mr. Myers' character, I have the highest opinion of him. He is of good family, sober, reliable, and conscious of the dignity of his Profession."

After spending three years in Mexico, Mr. Myers returned to his home in Virginia and was again engaged in local engineering around Winchester. In 1910, he entered the employ of the Virginia State

Highway Commission, under Mr. P. St. J. Wilson, having been located at Buena Vista, Big Stone Gap, and Fairfax, Va. While engaged at the latter place, in January, 1912, he was taken ill with typhoid fever and removed to the Georgetown University Hospital, where he remained under treatment for two months. Failing to improve, he was removed to his home in Winchester, where he died on April 4th, 1912.

Mr. Myers was always a student, and surrounded himself with the latest works on all branches of engineering. He was painstaking, and all his work and papers show that great care and precision were his marked characteristics. He was a member of the Presbyterian Church, and carried his love of God and man in his work, always living his religion.

Mr. Myers was elected an Associate Member of the American Society of Civil Engineers on October 3d, 1906.

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PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

(INSTITUTED 1852)

VOL. XXXVIII—No. 10
DECEMBER, 1912

Edited by the Secretary, under the direction of the Committee on Publications.

Reprints from this publication, which is copyrighted, may be made on condition that the full title of Paper, name of Author, page reference, and date of presentation to the Society, are given.

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NEW YORK 1912

Entered according to Act of Congress, in the year 1912, by the American Society of Civil Engineers, in the office of the Librarian of Congress, at Washington.

American Society of Civil Engineers

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◆

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day, and Christmas Day.

HOUSE OF THE SOCIETY—220 WEST FIFTY-SEVENTH STREET, NEW YORK.

TELEPHONE NUMBER....................5913 Columbus.
CABLE ADDRESS...................."Ceas, New York."

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*Filling the unexpired term of Vice-President Alfred P. Boller, who died December 9th, 1912.

†Vacancy caused by the death of Vice-President A. P. Boller.

‡Vacancy caused by the death of Director George A. Kimball on December 3d, 1912.

Vol. XXXVIII. DECEMBER, 1912. No. 10.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

PROCEEDINGS

This Society is not responsible for any statement made or opinion expressed in its publications.

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MINUTES OF MEETINGS

OF THE SOCIETY

November 20th, 1912.—The meeting was called to order at 8.30 P. M.; A. L. Bowman, M. Am. Soc. C. E., in the chair; Chas. Warren Hunt, Secretary; and present, also, 153 members and 21 guests.

A paper by A. W. Buel, M. Am. Soc. C. E., entitled "The Sewickley Cantilever Bridge Over the Ohio River," was presented by the Secretary, and illustrated with lantern slides. The paper was discussed orally by Messrs. C. W. Hudson and Lewis D. Rights, and written communications on the subject from Messrs. L. J. Le Conte, Charles Worthington, and Theodore A. Straub, were read by the Secretary.

A paper entitled "Ports of the Pacific," by H. M. Chittenden, M. Am. Soc. C. E., assisted by A. O. Powell, M. Am. Soc. C. E., was presented by title by the Secretary, who also read written communications on the subject from Messrs. L. J. Le Conte and Lewis M. Haupt. The paper was discussed orally by E. P. Goodrich, M. Am. Soc. C. E., who illustrated his remarks with lantern slides.

Adjourned.

December 4th, 1912.—The meeting was called to order at 8.30 P. M.; Director T. Kennard Thomson in the chair; Chas. Warren Hunt, Secretary; and present, also, 96 members and 16 guests.

The minutes of the meetings of October 16th and November 6th. 1912, were approved as printed in *Proceedings* for November, 1912.

A paper entitled "Tufa Cement, as Manufactured and Used on the Los Angeles Aqueduct," by J. B. Lippincott, M. Am. Soc. C. E., was presented by title. The Secretary read communications on the subject from Messrs. L. J. Le Conte and J. M. O'Hara, and the paper was discussed orally by Messrs. Luther Wagoner, E. D. Knap, G. A. Flynn, W. J. Boucher, and O. E. Mogensen.

A paper by E. G. Hopson, M. Am. Soc. C. E., entitled "The Economic Aspect of Seepage and Other Losses in Irrigation Systems," was also presented by title. Communications on the subject from Messrs. L. J. Le Conte and W. C. Hammatt, were read by the Secretary, and the paper was discussed orally by Luther Wagoner, M. Am. Soc. C. E.

The Secretary announced the election of the following candidates on December 3d, 1912.

As Members

Daniel Wheeler Bowman, Phœnixville, Pa.
William Stone Ide, Detroit, Mich.
Joseph Harris Kimball, Louisville, Ky.
Harry Snedden Laird, Cheat Haven, Pa.
John Mead, Dallas, Tex.
Lorenzo Perez Castro, City of Mexico, Mexico
Henry Gottlieb Raff, New York City
Carl Jonas Rhodin, San Francisco, Cal.
Walter Scott Wheeler, Lima, Peru
Francis Charles Williams, Sheridan, Wyo.
Frank Gordon Wolfe, Scranton, Pa.

As Associate Members

Normand Daggett Brainard, Springfield, Ohio
Elmer Hovey Brown, Hempstead, N. Y.
Fredric Sidney Burroughs, Olympia, Wash.
James Francis Curley, Pittsburgh, Pa.
Charles Stephen Dandois, Salladasburg, Pa.
Barry Dibble, Minidoka, Idaho
Robert Moore Dunham, Fort Worth, Tex.
William Howard Durbin, Evansville, Ind.
Francis Seeley Foote, Jr., Berkeley, Cal.
William Bradley Freeman, Bangkok, Siam
Fred Allen Gorham, Pompeys Pillar, Mont.
Ambrose Goulet Grandpré, Chicago, Ill.

Harry Rutledge Hall, Baltimore, Md.
Ivan Guy Harmon, Denver, Colo.
Ralph Zenas Kirkpatrick, Paraiso, Canal Zone, Panama
Geoffrey Wainman Mayo, Manila, Philippine Islands
Irwin Selden Osborn, Columbus, Ohio
Charles Joseph Renner, New Rochelle, N. Y.
Ned Hensel Sayford, York, Pa.
Benjamin Franklin Schaberg, St. Louis, Mo.
Brahma Nand Sharma, London, W. C., England
Milton Frederick Stein, Pittsburgh, Pa.
Kimbrough Enoch Voorhes, McGill, Nev.
Thomas Isaac Weston, Columbia, S. C.

As Juniors

Fritz Muss Arnolt, New York City
Arthur Francis de Jongh, Banes, Cuba
George Joseph Fisher, Coyote, Cal.
John Raymond James, Detroit, Mich.
Paul Sidney Jones, Fort Collins, Colo.
Harootun Hovhannes Khachadoorian, Burlington, Vt.
Lester William Perrin, Toronto, Ont., Canada
Karl Lewis Ponzer, Brinkley, Ark.
Daniel Henry Seaman, Newark, N. J.
Kirby Baldwin Sleppy, Los Angeles, Cal.
Henry Lawrence Thackwell, Chelan, Wash.
Franklin Thomas, Birmingham, Ala.
Newton Benjamin Wade, Millville, N. J.
John Croswell Warkley, Cheyenne, Wyo.
Alexander Woodward Yereance, Clanton, Ala.

The Secretary announced the transfer of the following candidates on December 3d, 1912:

From Associate Member to Member

Weston Earle Fuller, New York City
Oliver Thomas Reedy, Maxville, Mont.
Edward Augustus Southworth, Hilo, Hawaii

From Junior to Associate Member

Carl August Bock, St. Marc, Haiti
John Worde Caldwell, Honolulu, Hawaii
Rafael Sanchez Giquel, Havana, Cuba
Julius Reed Hall, Chicago, Ill.
Thomas Leach, Montreal, Que., Canada
Norris Raymond Macklem, Manila, Philippine Islands
William Watters Pagon, Baltimore, Md.

Earl Patterson, Selden, N. Mex.
Miguel Villa, Havana, Cuba
Albert Jones Willis, New York City

The Secretary announced the following deaths:

Daniel Seymour Brinsmade, elected Member, February 1st, 1888; died September 7th, 1912.

George Albert Kimball (*Director*), elected Junior, May 12th, 1875; Member, July 1st, 1891; died December 3d, 1912.

Adjourned.

December 18th, 1912.—Because of the necessity of going to press with this number of *Proceedings* in advance of this meeting, the publication of its minutes must be deferred until January, 1913. Two papers have been set down for discussion: "Prevention of Mosquito Breeding," by Spencer Miller, M. Am. Soc. C. E.; and "The Sanitation of Construction Camps," by Harold Farnsworth Gray, Jun. Am. Soc. C. E.

OF THE BOARD OF DIRECTION

(Abstract)

December 3d, 1912.—Vice-President Churchill in the chair; Chas. Warren Hunt, Secretary; and present, also, Messrs. Bush, Endicott, Gerber, Knap, Loomis, and Snow.

It was decided that the next meeting of the Board be held on the evening of January 7th, 1913, instead of December 31st, 1912.

It was decided that the first meeting of the Society in January be held on the evening of Wednesday, January 8th, instead of on January 1st, 1913.

President John A. Ockerson was nominated as a member of the John Fritz Medal Board of Award to take the place of Past-President Charles Macdonald, whose term of office on that Board will expire January 17th, 1913.

The following resolution which was unanimously adopted by the meeting of the Society, November 6th, 1912, was considered:

"*Resolved,* That a Special Committee of seven be appointed to codify present practice on the bearing value of soils for foundations, and report upon the physical characteristics of soils in their relation to engineering structures."

It was moved, seconded, and carried, that it is the sense of the Board that this Committee be appointed.

The Secretary reported that on November 8th, 1912, he had forwarded to Dr. J. H. T. Tudsbery, Honorary Treasurer, $900, being the result of 160 subscriptions from members of this Society to the proposed Lord Kelvin Memorial to be erected in the form of a memorial window in Westminster Abbey.

Messrs. George W. Tillson, Arthur S. Tuttle, and Chas. Warren Hunt, were appointed a Committee to take charge of the arrangements for the next Annual Meeting.

The following resolution adopted at the Annual Meeting of 1912 was considered:

"*Resolved,* That the Board of Direction be asked to consider a recurrence of the practice of providing a luncheon on the first day of the Annual Meeting."

On motion, duly seconded, it was resolved that it is the sense of this Board that the providing of this luncheon is not advisable.

The resignations of 4 members, 2 Associate Members, and 1 Associate, were accepted.

Ballots for membership were canvassed, resulting in the election of 11 Members, 24 Associate Members, and 15 Juniors, and the transfer of 10 Juniors to the grade of Associate Member.

Three Associate Members were transferred to the grade of Member.

Applications were considered, and other routine business transacted.

Adjourned.

ANNOUNCEMENTS

The House of the Society is open from 9 A. M. to 10 P. M., every day, except Sundays, Fourth of July, Thanksgiving Day, and Christmas Day.

FUTURE MEETINGS

January 8th, 1913.—8.30 P. M.—A regular business meeting will be held, and a paper by H. T. Cory, M. Am. Soc. C. E., entitled "Irrigation and River Control in the Colorado River Delta," will be presented for discussion.

This paper was printed in *Proceedings* for November, 1912.

Wednesday and Thursday, January 15th and 16th, 1913.—The Sixtieth Annual Meeting will be held. The Business Meeting will be called to order at 10 o'clock on Wednesday morning at the Society House. The Annual Reports will be presented, officers for the ensuing year elected, members of the Nominating Committee appointed, Reports of Special Committees presented for discussion, and other business transacted.

Arrangements for the Annual Meeting have been placed in the hands of the following committee: Messrs. George W. Tillson, Arthur S. Tuttle, and Charles Warren Hunt.

February 5th, 1913.—8.30 P. M.—This will be a regular business meeting. Two papers will be presented for discussion, as follows: "Characteristics of Cup and Screw Current Meters; Performance of These Meters in Tail-Races and Large Mountain Streams; Statistical Synthesis of Discharge Curves," by B. F. Groat, Assoc. M. Am. Soc. C. E.; and "The Infiltration of Ground-Water into Sewers," by John N. Brooks, Jun. Am. Soc. C. E.

These papers are printed in this number of *Proceedings.*

February 19th, 1913.—8.30 P. M.—Two papers will be presented for discussion at this meeting, as follows: "A Suggested Improvement in Building Water-Bound Macadam Roads," by J. L. Meem, Esq.; and "On Long-Time Tests of Portland Cement," by I. Hiroi, M. Am. Soc. C. E.

These papers are printed in this number of *Proceedings.*

SPECIAL MEETINGS FOR TOPICAL DISCUSSION

On the two days immediately following the Annual Meeting, three meetings of the Society will be held, at which the subject for discussion will be "Road Construction and Maintenance."

The meetings will be held as follows:

First Meeting, Friday, January 17th, 1913.—10 A. M.—The following sub-division of the subject will be discussed:

(1) "Cement-Concrete Pavements."

Second Meeting, Friday, January 17th, 1913.—2 P. M.—Two sub-divisions of the subject will be discussed:

(2) "Cost Records and Reports."

(3) "Design of Highway Systems."

Third Meeting, Saturday, January 18th, 1913.—10 A. M.—The following sub-division of the subject will be discussed:

(4) "Equipment for the Construction of Bituminous Surfaces and Bituminous Pavements."

SEARCHES IN THE LIBRARY

In January, 1902, the Secretary was authorized to make searches in the Library, upon request, and to charge therefor the actual cost to the Society for the extra work required. Since that time many searches have been made, and bibliographies and other information on special subjects furnished.

The resulting satisfaction, to the members who have made use of the resources of the Society in this manner, has been expressed frequently, and leaves little doubt that, if it were generally known to the membership that such work would be undertaken, many would avail themselves of it.

The cost is trifling compared with the value of the time of an engineer who looks up such matters himself, and the work can be performed quite as well, and much more quickly, by persons familiar with the Library.

In asking that such work be undertaken, members should specify clearly the subject to be covered, and whether references to general books only are desired, or whether a complete bibliography, involving search through periodical literature, is desired.

In reference to this work, the Appendices* to the Annual Reports of the Board of Direction for the years ending December 31st, 1906, and December 31st, 1910, contain summaries of all searches made to date.

PAPERS AND DISCUSSIONS

Members and others who take part in the oral discussions of the papers presented are urged to revise their remarks promptly. Written communications from those who cannot attend the meetings should be sent in at the earliest possible date after the issue of a paper in *Proceedings*.

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* *Proceedings*, Vol. XXXIII, p. 20 (January, 1907); Vol. XXXVII, p. 28 (January, 1911).

All papers accepted by the Publication Committee are classified by the Committee with respect to their availability for discussion at meetings.

Papers which, from their general nature, appear to be of a character suitable for oral discussion, will be published as heretofore in *Proceedings,* and set down for presentation to a future meeting of the Society, and, on these oral discussions, as well as written communications, will be solicited.

All papers which do not come under this heading, that is to say, those which from their mathematical or technical nature, in the opinion of the Committee, are not adapted to oral discussion, will not be scheduled for presentation to any meeting. Such papers will be published in *Proceedings* in the same manner as those which are to be presented at meetings, but written discussions, only, will be requested for subsequent publication in *Proceedings* and with the paper in the volumes of *Transactions.*

LOCAL ASSOCIATIONS OF MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Association

The San Francisco Association of Members of the American Society of Civil Engineers holds regular bi-monthly meetings, with banquet, and weekly informal luncheons. The former are held at 6 P. M., at the Palace Hotel on the third Friday of February, April, June, August, October, and December, the last being the Annual Meeting of the Association.

Informal luncheons are held at 12.15 P. M. every Wednesday, and the place of meeting may be ascertained by communicating with the Secretary of the Association, E. T. Thurston, Jr., M. Am. Soc. C. E., 713 Mechanics' Institute, 57 Post Street.

The by-laws of the Association provide for the extension of hospitality to any member of the Society who may be temporarily in San Francisco, and any such member will be gladly welcomed as a guest.

Colorado Association

The meetings of the Colorado Association of Members of the American Society of Civil Engineers are held on the second Saturday of each month, except July and August. The hour and place of meeting are not fixed, but this information will be furnished on application to the Secretary, Gavin N. Houston, M. Am. Soc. C. E., 409 Equitable Building, Denver, Colo. The meetings are usually preceded by an informal dinner. Members of the American Society of Civil Engineers will be welcomed at these meetings.

Weekly luncheons are held on Wednesdays, and, until further notice, will take place at the Colorado Traffic Club.

Visiting members are urged to attend the meetings and luncheons.

(Abstract of Minutes of Meetings)

September 14th, 1912. The meeting was called to order; President Ketchum in the chair; G. N. Houston, Secretary; and present, also, 20 members and 11 guests.

The subject for discussion, "The Cherry Creek Problem," was introduced by A. L. Fellows, M. Am. Soc. C. E., and was discussed by Messrs. Hunter, Bradley, Cranmer, Salter, Treise, Comstock, Prince, De Berard, and others.

Adjourned.

October 12th, 1912.—The meeting was called to order; President Ketchum in the chair; G. N. Houston, Secretary; and present, also, 18 members and 5 guests.

A paper entitled "The Construction of the Minnequa-Walsenbury Double-Track Line," was presented by A. O. Ridgway, M. Am. Soc. C. E., who illustrated his remarks with stereopticon views, and the subject was discussed generally by the members present.

Adjourned.

November 9th, 1912.—The meeting was called to order; President Ketchum in the chair; and present, also, 16 members and 4 guests.

The subject for discussion, "The Properties of Timber That Make for Durability," was opened by Mr. Norman DeW. Betts, of the United States Forestry Service, and Sam G. Porter, M. Am. Soc. C. E., who illustrated his remarks with lantern slides. A general discussion followed, in which the subject was presented from the viewpoint of the irrigation engineer by Messrs. Anderson and Ulrich; from the bridge and building standpoint by H. S. Crocker, M. Am. Soc. C. E.; from the viewpoint of the railroad engineer by Messrs. Vincent and Ridgway; and from the municipal tramway engineer's standpoint by R. W. Toll, Jun. Am. Soc. C. E.

Adjourned.

Atlanta Association

On March 14th, 1912, the Atlanta Association of Members of the American Society of Civil Engineers was organized, with the following officers: Arthur Pew, President; William A. Hansell, Jr., Secretary; and Messrs. James N. Hazlehurst and Alexander Bonnyman, Members of the Executive Committee. The Association will hold its meetings in the house of the University Club.

PRIVILEGES OF ENGINEERING SOCIETIES EXTENDED TO MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Members of the American Society of Civil Engineers will be welcomed by the following Engineering Societies, both to the use of their Reading Rooms and at all meetings:

American Institute of Mining Engineers, 29 West Thirty-ninth Street, New York City.

American Society of Mechanical Engineers, 29 West Thirty-ninth Street, New York City.

Architekten-Verein zu Berlin, Wilhelmstrasse 92, Berlin W. 66, Germany.

Associação dos Engenheiros Civis Portuguezes, Lisbon, Portugal.

Australasian Institute of Mining Engineers, Melbourne, Victoria, Australia.

Boston Society of Civil Engineers, 715 Tremont Temple, Boston, Mass.

Brooklyn Engineers' Club, 117 Remsen Street, Brooklyn, N. Y.

Canadian Society of Civil Engineers, 413 Dorchester Street, West, Montreal, Que., Canada.

Civil Engineers' Society of St. Paul, St. Paul, Minn.

Cleveland Engineering Society, Chamber of Commerce Building, Cleveland, Ohio.

Cleveland Institute of Engineers, Middlesbrough, England.

Dansk Ingeniorforening, Amaliegade 38, Copenhagen, Denmark.

Engineers' and Architects' Club of Louisville, Ky., 303 Norton Building, Fourth and Jefferson Streets, Louisville, Ky.

Engineers' Club of Baltimore, Baltimore, Md.

Engineers' Club of Minneapolis, 17 South Sixth Street, Minneapolis, Minn.

Engineers' Club of Philadelphia, 1317 Spruce Street, Philadelphia, Pa.

Engineers' Club of St. Louis, 3817 Olive Street, St. Louis, Mo.

Engineers' Club of Toronto, 96 King Street, West, Toronto, Ont., Canada.

Engineers' Society of Northeastern Pennsylvania, 302 Board of Trade Building, Scranton, Pa.

Engineers' Society of Pennsylvania, 219 Market Street, Harrisburg, Pa.

Engineers' Society of Western Pennsylvania, 2511 Oliver Building, Pittsburgh, Pa.

Institute of Marine Engineers, 58 Romford Road, Stratford, London, E., England.

Institution of Engineers of the River Plate, Buenos Aires, Argentine Republic.

Institution of Naval Architects, 5 Adelphi Terrace, London, W. C., England.

Junior Institution of Engineers, 39 Victoria Street, Westminster, S. W., London, England.

Koninklijk Instituut van Ingenieurs, The Hague, The Netherlands.

Louisiana Engineering Society, 321 Hibernia Bank Building, New Orleans, La.

Memphis Engineering Society, Memphis, Tenn.

Midland Institute of Mining, Civil and Mechanical Engineers, Sheffield, England.

Montana Society of Engineers, Butte, Mont.

North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne, England.

Oesterreichischer Ingenieur= und Architekten=Verein, Eschenbachgasse 9, Vienna, Austria.

Pacific Northwest Society of Engineers, 803 Central Building, Seattle, Wash.

Rochester Engineering Society, Rochester, N. Y.

Sachsischer Ingenieur- und Architekten-Verein, Dresden, Germany.

Sociedad Colombiana de Ingenieros, Bogota, Colombia.

Sociedad de Ingenieros del Peru, Lima, Peru.

Societe des Ingenieurs Civils de France, 19 Rue Blanche, Paris, France.

Society of Engineers, 17 Victoria Street, Westminster, S. W., London, England.

Svenska Teknologforeningen, Brunkebergstorg 18, Stockholm, Sweden.

Tekniske Forening, Vestre Boulevard 18–1, Copenhagen, Denmark.

Western Society of Engineers, 1737 Monadnock Block, Chicago, Ill.

ACCESSIONS TO THE LIBRARY

(From November 6th to December 3d, 1912)

DONATIONS*

A TEXT-BOOK ON ROADS AND PAVEMENTS.

By Frederick P. Spalding, M. Am. Soc. C. E. Fourth Edition, Revised and Enlarged. Cloth, 7½ x 5 in., illus., 11 + 408 pp. New York, John Wiley & Sons; London, Chapman & Hall, Limited, 1912. $2.00.

In the preface to the first edition of this work, it is stated that the author's aim has been to give a brief discussion, from an engineering standpoint, of the principles involved in highway work and to outline the more important systems of construction with a view to forming a text which may serve as a basis for a systematic study of the subject. Changes in the character of traffic, due to the introduction of automobiles, and modifications of the standards of life in city and country have caused, it is stated, a more careful and scientific study of materials for, and the use of more effectual methods in, the construction and maintenance of highways, and consequently many changes have been made in the subject-matter of the book. The third edition, issued in 1908, was practically rewritten, and the present edition includes new chapters on Bituminous Macadam and Concrete Pavements and the chapters on Brick, Asphalt and Wood Pavements have been considerably modified. The Chapter headings are: Road Economics and Management; Drainage of Streets and Roads; Location of Country Roads; Improvement and Maintenance of Country Roads; Broken-Stone Roads; Bituminous Macadam Roads; Foundations for Pavements; Brick Pavements; Asphalt Pavements: Wood-Block Pavements; Stone-Block Pavements; Concrete Pavements; City Streets.

STREET PAVEMENTS AND PAVING MATERIALS

A Manual of City Pavements: The Methods and Materials of Their Construction, for the Use of Students, Engineers, and City Officials. By George W. Tillson, M. Am. Soc. C. E. Second Edition. Cloth, 9¼ x 6 in., illus., 16 + 651 pp. New York, John Wiley & Sons; London, Chapman & Hall, Limited, 1912. $4.00.

The first edition of this book was published in 1900, since which time many types of new pavements have been introduced and the methods of constructing the older types greatly modified. These changes have necessitated, it is stated, changes in the text of this work, which include a complete revision of certain chapters and the addition of a new chapter on Concrete Pavements. The chapter on The Protection of Pavements is also new, and the author hopes it will prove especially useful in cities where much subsurface street construction is necessary. As stated in the secondary title, the volume is devoted to a study of the methods and materials for constructing city pavements, the subject of road construction being entirely ignored. The Chapter headings are: The History and Development of Pavements; Stone; Asphalt; Brick-Clays and the Manufacture of Paving Brick; Cement, Cement Mortar and Concrete; The Theory of Pavements; Cobble and Stone-Block Pavements; Asphalt Pavements; Brick Pavements; Wood Pavements; Broken-Stone Pavements; Concrete Pavements; Plans and Specifications; The Construction of Street-Car Tracks in Paved Streets; Width of Streets and Roadways, Curbs, Sidewalks, etc.; Asphalt Plants; The Protection of Pavements; Index.

THE MINING WORLD INDEX

Of Current Literature, Vol. 1, 1912. By Carpel L. Breger. Cloth, 9¼ x 6 in., 31 + 317 pp. Chicago, Mining World Company, 1912.

In a secondary title it is stated that this book is an international bibliography of mining and the mining sciences, namely, mining, ore dressing, metallurgy, assaying, geology, etc. It is a compilation and revision of the classified index of the world's current literature on mining, metallurgical, and the affiliated mineral industries which has appeared weekly in *Mining and Engineering World* since January, 1911. It will be issued in semi-annual volumes, of which the present volume is the first, being for the first semester of 1912, and is intended for the use of the practical miner, the mill man, the metallurgist, the layman, the operator, the student, and the trained or expert engineer. In this volume the larger subject headings are said to have been subdivided and all the different technical journals in which an article has appeared are indicated, a feature which, it is thought, will be appreciated by those whose library facilities are limited. The Contents are: I, Geography; II, Ores and Mineral Products; III, Technology; Explanations and Abbreviations; Author Index; Subject Index.

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* Unless otherwise specified, books in this list have been donated by the publishers.

RAILWAY TRANSPORTATION

A History of its Economics and of its Relation to the State. By Charles Lee Raper. Cloth, 8 x 5¼ in., 11 + 331 pp. New York and London, G. P. Putnam's Sons, 1912. $1.50.

The author's chief purpose in this book, which is intended for the general reader as well as the special student of railways, has been to revise and enlarge Hadley's "Railroad Transportation," on which, with the author's permission, it is based. The author states that the development of railway transportation has been so great and so important in its relation to the State since President Hadley's book was written in 1885 that it is vitally important to bring the subject down to the present. He traces the history of railway transportation, it is stated, in its more vital aspects, in the United States, Great Britain, France, Italy, and Germany, solely to throw light on the present management and regulation of railways, and, with his statements, includes comparisons and estimates of values. In the final chapter the statement of the reasons and methods as well as the history of State operation in various foreign countries, is said to be important. In order to ascertain the most reliable facts in connection with the subject, the author has personally examined records and the secondary sources as well as the conditions of the lines and equipment, the methods of operation, and the general characteristics of the traffic in all the countries which have come under treatment. The Contents are: Modern Transportation; Railway Transportation in Great Britain; Railway Transportation in France; Railway Transportation in Italy; Railway Transportation in Germany; Railway Transportation in the United States; State Operation of Railways; Extension of Parcels Post, etc.; Index.

HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES

For Buyers and Sellers. Twenty-first Annual Edition. Cloth, 10½ x 7½ in., illus., 122 + 1576 pp. New York, Samuel E. Hendricks Co., 1912. $10.00.

This volume, which is devoted to the interests of the architectural, mechanical, engineering, contracting, electrical, railroad, iron, steel, hardware, mining, mill, quarrying, exporting, and kindred industries, is stated to be a complete and reliable annual index of these industries, containing more than 350 000 names and addresses and upward of 40 000 business classifications. It is said to be indispensable as a buyer's reference and for mailing purposes, and gives full lists of manufacturers of and dealers in everything used in the manufacture of material, machinery, and apparatus for these industries, from the raw material to the manufactured article and from the producer to the consumer. Its contents are arranged alphabetically by subject, under which are given, in alphabetical order and in some cases by States and cities, the names and addresses of firms dealing in a particular article, and sometimes these are followed by detailed matter, titles of identification, trade names, etc. There is also an alphabetical list of advertisers including the addresses of their domestic and foreign branches, a simplified discount sheet for the purchasing agent, and an index to contents of 122 pages.

SCIENTIFIC MANAGEMENT:

Addresses and Discussions at the First Conference at the Amos Tuck School, Dartmouth College, Held October 12th-14th, 1911. Cloth, 9¼ x 6 in., illus., 11 + 388 pp. Hanover, N. H., Dartmouth College, 1912. (Donated by Harlow S. Person). $2.75.

In an address on Scientific Management before the Social Science Club and the Dartmouth Scientific Society of Dartmouth College, Harlow S. Person, Director of the Amos Tuck School of Administration and Finance, stated that the purpose of this first Tuck School Conference was to enable business men and manufacturers of New Hampshire and of New England to meet the organizing engineers who have applied scientific management and the manufacturers in whose plants it is in operation. As stated in the title, this volume is made up of the addresses and discussions at this Conference, which, it is hoped, will aid in a better understanding of the principles of scientific management and of its applicability to various businesses. The Contents are: Introduction: Scientific Management, by Harlow S. Person. I, The Principles of Scientific Management, by Frederick W. Taylor.

II, Scientific Management and the Laborer: The Task and the Day's Work, by Henry L. Gantt; The Opportunity of Labor Under Scientific Management, by Harrington Emerson. III, Scientific Management and the Manager: Types of Management—Unsystematized, Systematized, and Scientific, by Henry P. Kendall; The Spirit in Which Scientific Management Should be Approached, by James M. Dodge. IV, Discussions on the Applicability of Scientific Management in Certain Industries: Machine Manufacture; Textile Manufacture; Shoe Manufacture; Printing and Publishing; Pulp and Paper Manufacture; Lumbering, and the Management of Timber Properties; Academic Efficiency. V, Scientific Management and Government: The Application of Scientific Management to the Activities of State and Municipal Government, by Frederick A. Cleveland. VI, Phases of Scientific Management: Symposium; Registration at the Conference.

McGRAW ELECTRIC RAILWAY MANUAL, 1912.

The Red Book of American Street Railway Investments. Edited by Frederic Nicholas. Nineteenth Annual Number. Cloth, 13 x 10 in., illus., 32 + 344 pp. New York, McGraw Publishing Company, 1912. $5.00.

This book, it is stated in a secondary title, is a manual, issued in connection with the *Electric Railway Journal*, of securities, traffic statistics, earnings, officers, directors, and equipment of street and interurban railways in the United States, Canada, Mexico, Cuba, and the West Indies. The general arrangement of the subject-matter, as given in previous issues, is followed in this volume, alphabetically by States and cities with the history, capital stock, funded debt, mortgages, track and equipment, names and addresses of officers, and addresses of the general offices and repair shops of each company. There are maps showing the main and connecting lines of many of the larger companies and, at the end of the book, is given a list of the various street and interurban railway associations with the names and addresses of their officers. The gross earnings of electric railway companies are given, as well as the changes shown by the 1912 edition of the Manual, details of operating statements, and a list of companies with gross earnings in 1911 of more than $1 000 000. There is an index of ten pages of the companies described in the Manual.

STRUCTURAL DETAILS OF HIP AND VALLEY RAFTERS.

By Carlton Thomas Bishop. Cloth, 8 x 10¾ in., illus., 5 + 72 pp. New York, John Wiley and Sons; London, Chapman and Hall, Limited, 1912. $1.75.

The author states that his purpose in this book is to present the subject of hip and valley construction so completely that any draftsman with a reasonable knowledge of structural details and of trigonometry can make working drawings which shall give all necessary information to the shop without useless refinements. No attempt has been made, it is stated, to show the application to skew portals, hoppers, or chutes, but it is felt that the fomulas will be of great assistance to draftsmen when dealing with these problems. Complete directions are given, it is said, for making shop drawings for the steelwork of intersecting roofs and similar structures, the notes for the various cases being arranged for convenient reference and illustrated by general drawings and typical problems. The algebraic and graphic methods of obtaining the necessary numerical values are fully explained, and, at the end of the book, tables are given to assist in the solution of problems which are most likely to occur in practice. The Contents are: General Outline; Flange Connection; Web Connection; Notes on Other Cases; Derivation of Formulas; Graphic Method of Determining Angles; Values and Logarithms for Common Cases.

THE DESIGN OF SIMPLE ROOF-TRUSSES IN WOOD AND STEEL

With an Introduction to the Elements of Graphic Statics. By Malverd A. Howe, M. Am. Soc. C. E. Third Edition, Revised and Enlarged. Cloth, 9¼ x 6 in., illus., 8 + 179 pp. New York, John Wiley & Sons; London, Chapman & Hall, Limited, 1912. $2.00.

In the preface to the first edition of this work, published in 1902, the author states that his object was to bring together all the essentials necessary to the proper design of ordinary roof-trusses in wood and steel, which, previous to that date, had been accessible only in the various comprehensive treatises on the subject and in manufacturers' pocket-books. In this edition considerable new matter, it is stated, will be found in the body of the text and in the Appendix. The design of details in wood has also been revised, the standard or actual sizes of wood being used instead of the nominal sizes. The Chapter headings are: General Principles and Methods; Beams and Trusses; Strength of Materials; Roof Trusses and Their Design; Design of a Wooden Roof-Truss; Design of a Steel Roof-Truss; Tables; Appendix; Index.

AN OUTLINE OF THE METALLURGY OF IRON AND STEEL.

By A. Humboldt Sexton and J. S. G. Primrose. Second Edition. Cloth, 8¾ x 5¾ in., illus., 16 + 572 pp. Manchester, England, The Scientific Publishing Company, 1912. 12 shillings 6 pence.

This book, it is stated, was prepared to meet the need of one of the authors in his teaching, namely, a book which in one volume of moderate size would cover the whole field of the metallurgy of iron and steel. This, the second edition, has been carefully revised and some of the chapters have been rewritten in order, it is said, to bring the subject-matter up to date. All the more important developments in processes and plant are described, only such descriptions of the older processes being retained as are necessary to an understanding of modern development and historical interest. Considerable attention has been given, it is stated, in this edition to the metallography and heat treatment of the metal. Numerous references to original papers are included, and the authors urge their readers, especially students, to make a study of these papers and the methods described in them. The Contents are: Part I, Introductory; Part II, Iron; Part III, Malleable Iron; Part IV, Steel; Appendix; Index.

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK, 1913.

Edited by William H. Fowler. Fifteenth Annual Edition. Leather, 6¼ x 4 in., illus., 66 + 592 pp. Manchester, England, Scientific Publishing Co., 1912. 2 shillings 9 pence.

The Contents are: Miscellaneous Tables and Formulæ; Steam Boilers and Fittings; Fuels and Combustion; Steam Engines; Steam Turbines; Locomotives; Steam Tables; Valves and Valve Gear; Gas Engines; Gases Used in Gas Engines; Oil Engines; Hydraulics; Pumps and Pumping Arrangements; Gearing and Lubrication; Hoisting and Lifting Machinery; Mining Machinery and Appliances; Iron and Steel; Metals and Alloys; Beams and Pillars; Springs; Chemistry; Ventilation and Heating; Index.

MODERN HOSPITALS:

A Series of Authoritative Articles on Planning and Equipment, as Exemplified by the Best Practice in This Country and Europe. By Edward F. Stevens and others. Cloth, 12½ x 9¼ in., illus., 49 + 86 pp. New York, The American Architect, 1912. $5.00.

The preface states that the subject-matter of this book is descriptive of the latest word on hospital construction, arrangement, and equipment, based on the best modern practice, and that it is intended as an aid to architects and those concerned with the superintendence of hospitals and the care of the sick. The text is supplemented by many illustrations of recently constructed hospitals, for special and general fields, consisting of floor plans, elevations, perspectives, and illustrations of interiors and of technical equipments. A partial list of Contents is: Details and Equipment of Hospitals, by Edward F. Stevens; Modern Practice in Hospital Heating and Ventilation, by Clarence W. Williams; Some Essentials of Hospital Heating and Ventilation, by D. D. Kimball; Hospital Lighting, by E. H. Bostock; The Artificial Lighting of Hospitals, by John Darch; Co-operation in Hospital Planning, by M. E. McCalmont; A Tropical Hospital Adaptable for Tuberculosis, by M. E. McCalmont; Descriptions and Illustrations of the Barnard Skin and Cancer Hospital; Contagious Group of the Providence, R. I., City Hospital; Brooklyn Seaside Hospital for Children: St. Vincent's Hospital, Indianapolis, Ind.; the New Bellevue Hospital, New York City; the Rockefeller Institute for Medical Research, New York City, etc., etc.

A TREATISE ON CEMENT SPECIFICATIONS.

By Jerome Cochran, Jun. Am. Soc. C. E. Cloth, 8½ x 5½ in., illus., 12 + 101 pp. New York, D. Van Nostrand Company, 1912. $1.00.

In a secondary title it is stated that this treatise includes the general use, purchase, storage, inspection, and test requirements of Portland, natural, puzzolan (slag), and silica (sand) cements, together with methods of testing and analysis of Portland cement. The author's aim has been to present a set of specifications for cement in a form for convenient practical use and ready reference, which will be consistent and conform to modern practice. In order to enable the student or young engineer to study the methods used by others in drawing up cement specifications, the author has included numerous but carefully selected references to specification requirements for cement contained in engineering periodicals and the transactions of engineering societies. The Contents are: Introduction; General Conditions Governing Use of Cement; Furnishing Cement to the Contractor; Purchase of Cement from Manufacturers; Delivery and Storage of Cement; Inspection and Tests of Cement; Test Requirement for Cement; Methods of Testing Cement; Significance of Tests of Cement; Methods of Chemical Analysis of Portland Cement; Bibliography of Specifications for Cement; Bibliography of Foreign Cement Specifications; Index.

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Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, insbesondere aus den Laboratorien der technischen Hochschulen. Herausgegeben vom Verein deutscher Ingenieure. Hefte 121–124. Julius Springer, Berlin, 1911.

Smoke: A Study of Town Air. By Julius B. Cohen and Arthur G. Ruston. Edward Arnold, London, 1912.

Historical Papers on Modern Explosives. By George W. MacDonald, With an Introduction by *Sir* Andrew Noble. Whittaker & Co., New York and London, 1912.

The Electric Circuit. By V. Karopetoff. Second Edition. McGraw-Hill Book Co., New York and London, 1912.

Skeleton Construction in Buildings; With Numerous Practical Illustrations of High Buildings. By William H. Birkmire. Fourth Edition. John Wiley & Sons, New York; Chapman & Hall, Ltd., London, 1907.

Methods of Air Analysis. By J. S. Haldane. Charles Griffin & Co., Ltd., London, 1912.

The Mechanical Engineering of Collieries. By T. Campbell Futers. Vol. 2, Revised and Enlarged. The Colliery Guardian Co., Ltd., London, 1910.

Vorlesungen über Ingenieur=Wissenschaften. Von Georg Christoph Mehrtens. Erster Teil. Statik und Festigkeitstlehre. Dritter Band, Zweite Hälfte. Wilhelm Engelmann, Leipzig, 1912.

Modern Brickmaking. By Alfred B. Searle. D. Van Nostrand Co., New York; Scott, Greenwood & Son, London, 1911.

SUMMARY OF ACCESSIONS

(From November 6th to December 3d, 1912)

Donations (including 41 duplicates)	564
By purchase	12
Total	576

MEMBERSHIP

ADDITIONS

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Palmer, George Bruce. Const. Engr., Michigan Alkali Co., Wyandotte, Mich.		Sept. 3, 1912
Saph, Augustus Valentine. 2330 Durant Ave., Berkeley, Cal.	Assoc. Assoc. M. M.	Oct. 1, 1901 June 4, 1907 Oct 29, 1912
Sutton, Charles Wood. Chf. Engr., Peruvian Irrig. Service, Apartado 889, Lima, Peru	Jun. Assoc. M. M.	Dec. 1, 1903 Dec. 6, 1905 Sept. 3, 1912
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Stine, Walter Pearce. 705 Elgie St., Beaumont, Tex.		Oct. 1, 1912
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JUNIORS

Bailey, Russel Thomas. Res. Engr., Ambursen Hydr. Constr. Co., Branson, Mo.	May 28, 1912
Boerner, Francis Clarence. Care, Turner Constr. Co., 11 Broadway (Res., 228 Edgecombe Ave.,) New York City	Oct. 29, 1912

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Horwege, Alvin Arthur. Asst. Engr., State Board Harbor Commrs., 1418 Larkin St., San Francisco, Cal...	Oct. 29, 1912
Kelly, Hugh Ambrose. Engr. and Asst. Secy., City Plan Comm., 33 Baldwin Ave., Jersey City, N. J.........	Oct. 29, 1912
Page, Percy Harold. Senior Draftsman, Rees & Kirby, Ltd., Morriston, near Swansea, Wales.............	May 28, 1912
Patterson, Charles Scott. Asst. Engr., M., K. & T. of T. Ry., Greenville, Tex..............................	Oct. 29, 1912
Shaw, Guy Ray. 810 Observatory Bldg., Des Moines, Iowa.	May 28, 1912
Williams, Frederick. Surv. and Draftsman, Care, U. S. Engr. Office, New London, Conn..................	Oct. 29, 1912

DEATHS

Brinsmade, Daniel Seymour. Elected Member, February 1st, 1888; died September 7th, 1912.

Kimball, George Albert. (*Director.*) Elected Junior, May 12th, 1875; Member, July 1st, 1891; died December 3d, 1912.

Total Membership of the Society, December 5th, 1912,
6 781

MONTHLY LIST OF RECENT ENGINEERING ARTICLES OF INTEREST

(November 6th to December 4th, 1912)

NOTE.—*This list is published for the purpose of placing before the members of this Society, the titles of current engineering articles, which can be referred to in any available engineering library, or can be procured by addressing the publication directly, the address and price being given wherever possible.*

LIST OF PUBLICATIONS

In the subjoined list of articles, references are given by the number prefixed to each journal in this list:

(1) *Journal,* Assoc. Eng. Soc., Boston, Mass., 30c.
(2) *Proceedings,* Engrs. Club of Phila., Philadelphia, Pa.
(3) *Journal,* Franklin Inst., Philadelphia, Pa., 50c.
(4) *Journal,* Western Soc. of Engrs., Chicago, Ill., 50c.
(5) *Transactions,* Can. Soc. C. E., Montreal, Que., Canada.
(6) *School of Mines Quarterly,* Columbia Univ., New York City, 50c.
(7) *Gesundheits Ingenieur,* München, Germany.
(8) *Stevens Institute Indicator,* Hoboken, N. J., 50c.
(9) *Engineering Magazine,* New York City, 25c.
(10) *Cassier's Magazine,* New York City, 25c.
(11) *Engineering* (London), W. H. Wiley, New York City, 25c.
(12) *The Engineer* (London), International News Co., New York City, 35c.
(13) *Engineering News,* New York City, 15c.
(14) *Engineering Record,* New York City, 10c.
(15) *Railway Age Gazette,* New York City, 15c.
(16) *Engineering and Mining Journal,* New York City, 15c.
(17) *Electric Railway Journal,* New York City, 10c.
(18) *Railway and Engineering Review,* Chicago, Ill., 15c.
(19) *Scientific American Supplement,* New York City, 10c.
(20) *Iron Age,* New York City, 20c.
(21) *Railway Engineer,* London, England, 1s. 2d.
(22) *Iron and Coal Trades Review,* London, England, 6d.
(23) *Bulletin,* American Iron and Steel Assoc., Philadelphia, Pa.
(24) *American Gas Light Journal,* New York City, 10c.
(25) *American Engineer,* New York City, 20c.
(26) *Electrical Review,* London, England, 4d.
(27) *Electrical World,* New York City, 10c.
(28) *Journal,* New England Water-Works Assoc., Boston, Mass., $1.
(29) *Journal,* Royal Society of Arts, London, England, 6d.
(30) *Annales des Travaux Publics de Belgique,* Brussels, Belgium, 4 fr.
(31) *Annales* de l'Assoc. des Ing. Sortis des Ecoles Spéciales de Gand, Brussels, Belgium, 4 fr.
(32) *Mémoires et Compte Rendu des Travaux,* Soc. Ing. Civ. de France, Paris, France.
(33) *Le Génie Civil,* Paris, France, 1 fr.
(34) *Portefeuille Economiques des Machines,* Paris, France.
(35) *Nouvelles Annales de la Construction,* Paris, France.
(36) *Cornell Civil Engineer,* Ithaca, N. Y.
(37) *Revue de Mécanique,* Paris, France.
(38) *Revue Générale des Chemins de Fer et des Tramways,* Paris, France.
(39) *Technisches Gemeindeblatt,* Berlin, Germany, 0, 70m.
(40) *Zentralblatt der Bauverwaltung,* Berlin, Germany, 60 pfg.
(41) *Elektrotechnische Zeitschrift,* Berlin, Germany.
(42) *Proceedings,* Am. Inst. Elec. Engrs., New York City, $1.
(43) *Annales des Ponts et Chaussées,* Paris, France.
(44) *Journal,* Military Service Institution, Governors Island, New York Harbor, 50c.
(45) *Mines and Minerals,* Scranton, Pa., 25c.
(46) *Scientific American,* New York City, 15c.
(47) *Mechanical Engineer,* Manchester, England, 3d.
(48) *Zeitschrift,* Verein Deutscher Ingenieure, Berlin, Germany, 1, 60m.
(49) *Zeitschrift für Bauwesen,* Berlin, Germany.
(50) *Stahl und Eisen,* Düsseldorf, Germany.
(51) *Deutsche Bauzeitung,* Berlin, Germany.
(52) *Rigasche Industrie-Zeitung,* Riga, Russia, 25 kop.
(53) *Zeitschrift,* Oesterreichischer Ingenieur und Architekten Verein, Vienna, Austria, 70h.

(54) *Transactions,* Am. Soc. C. E., New York City, $4.
(55) *Transactions,* Am. Soc. M. E., New York City, $10.
(56) *Transactions,* Am. Inst. Min. Engrs., New York City, $6.
(57) *Colliery Guardian,* London, England, 5d.
(58) *Proceedings,* Engrs.' Soc. W. Pa., 803 Fulton Bldg., Pittsburgh, Pa., 50c.
(59) *Proceedings,* American Water-Works Assoc., Troy, N. Y.
(60) *Municipal Engineering,* Indianapolis, Ind., 25c.
(61) *Proceedings,* Western Railway Club, 225 Dearborn St., Chicago, Ill., 25c.
(62) *Industrial World,* 59 Ninth St., Pittsburgh, Pa., 10c.
(63) *Minutes of Proceedings,* Inst. C. E., London, England.
(64) *Power,* New York City, 5c.
(65) *Official Proceedings,* New York Railroad Club, Brooklyn, N. Y., 15c.
(66) *Journal of Gas Lighting,* London, England, 6d.
(67) *Cement and Engineering News,* Chicago, Ill., 25c.
(68) *Mining Journal,* London, England, 6d.
(69) *Der Eisenbau,* Leipzig, Germany.
(70) *Engineering Review,* New York City, 10c.
(71) *Journal,* Iron and Steel Inst., London, England.
(71*a*) *Carnegie Scholarship Memoirs,* Iron and Steel Inst., London, England.
(72) *American Machinist,* New York City, 15c.
(73) *Electrician,* London, England, 18c.
(74) *Transactions,* Inst. of Min. and Metal., London, England.
(75) *Proceedings,* Inst. of Mech. Engrs., London, England.
(76) *Brick,* Chicago, Ill., 10c.
(77) *Journal,* Inst. Elec. Engrs., London, England, 5s.
(78) *Beton und Eisen,* Vienna, Austria, 1, 50m.
(79) *Forscherarbeiten,* Vienna, Austria.
(80) *Tonindustrie Zeitung,* Berlin, Germany.
(81) *Zeitschrift für Architektur und Ingenieurwesen,* Wiesbaden, Germany.
(82) *Mining and Engineering World,* Chicago, Ill., 10c.
(83) *Progressive Age,* New York City, 15c.
(84) *Le Ciment,* Paris, France.
(85) *Proceedings,* Am. Ry. Eng. Assoc., Chicago, Ill.
(86) *Engineering-Contracting,* Chicago, Ill., 10c.
(87) *Railway Engineering and Maintenance of Way,* Chicago, Ill., 10c.
(88) *Bulletin* of the International Ry. Congress Assoc., Brussels, Belgium.
(89) *Proceedings,* Am. Soc. for Testing Materials, Philadelphia, Pa., $5.
(90) *Transactions,* Inst. of Naval Archts., London, England.
(91) *Transactions,* Soc. Naval Archts. and Marine Engrs., New York City.
(92) *Bulletin,* Soc. d'Encouragement pour l'Industrie Nationale, Paris, France.
(93) *Revue de Métallurgie,* Paris, France, 4 fr. 50.
(94) *The Boiler Maker,* New York City, 10c.
(95) *International Marine Engineering,* New York City, 20c.
(96) *Canadian Engineer,* Toronto, Ont., Canada, 10c.
(98) *Journal,* Engrs. Soc. Pa., Harrisburg, Pa., 30c.
(99) *Proceedings,* Am. Soc. of Municipal Improvements, New York City, $2.
(100) *Professional Memoirs,* Corps of Engrs., U. S. A., Washington, D. C., 50c.
(101) *Metal Worker,* New York City, 10c.
(102) *Organ für die Fortschritte des Eisenbahnwesens,* Wiesbaden, Germany.
(103) *Mining and Scientific Press,* San Francisco, Cal., 10c.
(104) *The Surveyor and Municipal and County Engineer,* London, England, 6d.
(105) *Metallurgical and Chemical Engineering,* New York City, 25c.
(106) *Transactions,* Inst. of Mining Engrs., London, England, 6s.
(107) *Schweizerische Bauzeitung,* Zürich, Switzerland.
(108) *Southern Machinery,* Atlanta, Ga., 10c.

LIST OF ARTICLES

Bridges.

A Four-Track, Center-Bearing Railroad Draw Span.* Louis H. Shoemaker, M. Am. Soc. C. E. (54) Vol. 75.

Specifications for the Design of Bridges and Subways.* Henry B. Seaman, M. Am. Soc. C. E. (54) Vol. 75.

The St. Croix River Bridge.* C. A. P. Turner, M. Am. Soc. C. E. (54) Vol. 75.

Notes on the Construction of the Charles River Bridge, East Cambridge Extension of the Boston Elevated Railway Company.* Clarence T. Fernald. (Paper read before the Boston Soc. of Civ. Engrs.) (1) Nov.

Black Rock Harbor Swing Span, G. T. Ry.* R. D. Garner. (87) Nov.

Construction of the Concrete Viaduct between Dallas and Oak Cliff, Texas.* E. N. Noyes. (14) Nov. 9.

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*Illustrated.

Bridges—(**Continued**).

Method of Constructing Piers for the New Double Track Deck Plate Girder Bridge over Cedar River at Moscow, Ia. C. E. Ziegenbein. (86) Nov. 13.
A Three Span, Pony Truss Street Bridge with Concrete Protected Floor Over Railway Tracks.* A. W. Carpenter. (86) Nov. 13.
Automatic Car-Bumpers and Barriers for Drawbridge Approaches.* (13) Nov. 14.
Computation and Fabrication Details, Sewickley Bridge. (14) Nov. 16.
Methods and Cost of Constructing the Stony Brook Glen Viaduct, Pittsburgh, Shawmut & Northern Railway.* H. S. Wilgus. (86) Nov. 20.
New Louisville Bridge Across the Ohio, Erecting Very Long and Heavy Simple Spans by the Cantilever Method.* (14) Nov. 23.
Construction Features of the Kingshighway Viaduct, St. Louis, Missouri, Reinforced Concrete Arches with Hollow Piers and Retaining Wall Approaches.* (14) Nov. 23.
Grade Elimination and Railroad Bridges. C. H. Tinker. (Paper read before the Cleveland Eng. Soc.) (96) Nov. 28.
Concrete Street Underpass Beneath Six Tracks.* (14) Nov. 30.
Progress on Quebec Bridge Substructure.* (14) Nov. 30.
Superstructure of the East Haddam Bridge.* (14) Nov. 30.
Building Bridge Piers Adjacent to a Masonry Dam.* (14) Nov. 30.
Penn Street Viaduct at Reading, Pennsylvania.* (14) Nov. 30.
Notice sur la Reconstruction du Pont de la Roche-Bernard (Morbihan).* Bénézit et Tarnier. (43) Sept.
Calcul des Ponts de Chemins de Fer à Poutres Droites et à Travées Indépendantes sous l'Action d'une Charge Uniformément Répartie, Concentrée au Droit des Montants des Poutres Principales.* E. Pentecôte. (38) Serial beginning Nov.
Pont-Route en Arc, de 200 Mètres d'Ouverture sur la Vilaine, à la Roche-Bernard (Morbihan).* Ch. Dantin. (33) Nov. 16.
Gutachten über die Ursachen des Einsturzes des Lehrgerüstes des Val Mela-Viaduktes.* R. Weber und S. Grosjean. (107) Nov. 23.

Electrical.

Characteristic Ornamental Street Lighting.* (60) Nov.
The Advance in Street Lighting.* (60) Nov.
Electric Welding. Francis H. Davies. (108) Nov.
Street Lighting at Manchester. Haydn T. Harrison and Jacques Abady. (Report to the Manchester City Council.) (73) Nov. 1; (66) Oct. 29.
Electricity at Stoneleigh Abbey.* (26) Nov. 1.
Recent Developments in Automatic Exchange Telephone Systems.* G. H. Green. (73) Serial beginning Nov. 8.
Saturation Currents in Selenium.* F. Kaempf. (Translated from *Phys. Zeitschrift.*) (73) Nov. 8.
Automatic Voltage Regulation of Alternating-Current Generators. Lester McKenney. (27) Nov. 9.
Electric Winding Engines.* A. E. du Pasquier. (Abstract of paper read before the South Wales Inst. of Engrs.) (73) Nov. 15.
Radiant Efficiency of Incandescent Filaments.* W. E. Forsythe. (Abstract from *Physical Review.*) (73) Nov. 15.
High-Tension Equipment for Electrical Plants. J. R. Wilson. (Abstract of paper read before the American Electrochemical Soc.) (73) Nov. 15.
More Notes on Electric Welding.* V. D. Green. (Paper read before the Birmingham and District Electric Club.) (26) Serial beginning Nov. 15.
New Power Station and Line Construction in Lexington.* (17) Nov. 16; (27) Nov. 16.
Electrical Equipment of the Works of the Shelton Iron, Steel, and Coal Company, Limited.* (22) Nov. 22.
Electric Haulage Gear for India.* (22) Nov. 22.
Standard Methods Recommended for Testing Dry Cells. (Abstract of Report of Committee, Am. Electro-Chemical Soc.) (73) Nov. 22.
Central-Station Practice at Halifax, N. S.* (27) Nov. 23.
The Thury System of Power Transmission by Continuous Currents.* Alfred Still. (27) Serial beginning Nov. 23.
High-Tension Distribution in Northern Illinois.* (27) Nov. 23.
Some Developments in Wireless. John Hays Hammond, Jr. (46) Serial beginning Nov. 23.
Structural-Steel Towers and Poles.* R. Fleming. (13) Nov. 28.
Hydroelectric Energy for Coal Fields.* (27) Nov. 30.
Stroboscopic Effects Obtainable with Incandescent Filaments as Illuminants.* C. F. Lorenz. (27) Nov. 30.
The Lamb Process of Protecting Poles from Decay.* (18) Nov. 30.
Rates for Electricity. Henry D. Jackson. (9) Dec.; (64) Nov. 12.
Gas Lighting *versus* Electrical Lighting for Public Streets of Large Towns. (24) Dec. 2.
Calculs de Résistance des Lignes Electriques.* (34) Nov.

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Electrical—(Continued).

Atmosphärische Störungen in der drahtlosen Telegraphie.* Mosler. (41) Oct. 31.
Zur Beurteilung des Anwendungsgebietes von Starklichtquellen, insbesondere von Drehstromlampen.* Walter Schäffer. (41) Nov. 7.
Feuertelegraphie.* W. Fellenberg. (41) Nov. 14.
Die magnetische Prüfung von Eisenblech. J. Epstein. (41) Nov. 14.
Ueber Telephonstörungen durch Wechselstrombahnen und einige Vorgänge in Einphasengeneratoren.* F. Marguerre. (41) Nov. 21.

Marine.

The Ultimate Dimensions of the Largest Seagoing Vessels. C. E. Grunsky. (Paper read before the Technical Soc. of the Pacific Coast.) (1) Nov.
The Motor Ship *Juno*.* (12) Serial beginning Nov. 15.
Gasoline Car-Ferry for an Electric Railway.* (13) Nov. 21.
The Largest Side-Wheel Steamer in the World. (13) Nov. 21.
Motor Ship *Rolandseck*.* (12) Nov. 22.
The French Trans-Atlantic Liner *Rochambeau*.* (11) Serial beginning Nov. 22.
Salvage and Testing Facilities for Submarines.* R. G. Skerrett. (46) Nov. 23.
The First Italian Dreadnought *Dante Aighieri*.* Dagnino Attilio. (95) Dec.
Les Moteurs Sulzer-Diesel à Deux Temps du Cargo *Monte Penedo*.* Ch. Dantin. (33) Oct. 26.
See-Bekohleinrichtungen für Schiffe.* Wintermeyer. (48) Oct. 5.

Mechanical.

Modern Boiler Problems. E. D. Meier. (Paper read before the Stevens Eng. Soc.) (8) Oct.
Liquid Fuel, Its Use and Abuse. W. N. Best. (65) Oct. 18; (108) Nov.
Autogenous Welding of Copper and Aluminum.* F. Carnevali. (Paper read before the Inst. of Metals.) (47) Oct. 25.
Manchester Street Lighting. Haydn T. Harrison and Jacques Abady. (Report made to Manchester City Council.) (66) Oct. 29; (73) Nov. 1.
A Modern Plant for Preparing Sand and Gravel.* (67) Nov.
Dirigibles and Aeroplanes in Germany. R. H. Hare. (Translated from *Le Revue Militaire des Armées Etrangères*.) (44) Nov.
Park Works, Newton Heath, Manchester.* (12) Nov. 1.
Oil Fuel and the Corrosion of Boilers. C. E. Stromeyer. (Paper read before the Manchester Steam Users' Assoc.) (73) Nov. 1.
Reliability in High Lift Centrifugal Pumps.* W. E. W. Millington. (Paper read before the Manchester Assoc. of Engrs.) (47) Nov. 1; (12) Nov. 1.
Skeleton Patterns on Large Work.* N. Johnson. (72) Nov. 7.
Gaseous Explosions.* (Report of Committee for Investigation of Gaseous Explosions. Paper read before the British Assoc.) (11) Nov. 8.
Development in Auxiliary Units Between Exhaust-Pipe and Boiler.* William Weir. (Abstract of paper read before the Institution of Engrs. and Shipbuilders in Scotland.) (11) Nov. 8; (47) Nov. 1.
The Raw Materials of the Portland Cement Industry. Percy S. Barber. (12) Serial beginning Nov. 8.
Whirling-Table at East London College.* A. P. Thurston. (11) Nov. 8.
Four-Cylinder Vertical Gas-Engine. (11) Nov. 8.
Mechanical Handling of Baggage and Freight. William C. Carr. (Abstract of paper read before the New England Railroad Club.) (15) Nov. 8.
British Steam Turbo-Generator Station.* (27) Nov. 9.
Reconstruction of an Old Retort House. Howard E. Mann. (Paper read before the Canada-Michigan Gas Assoc.) (24) Nov. 11.
The Chapman Rotary Gas Producer.* (62) Nov. 11.
Steam Consumption Computations.* J. A. Knesche. (64) Nov. 12.
Study of the Shadowgraph Test for Gas-Fires.* W. J. A. Butterfield, Assoc. Inst. C. E. (66) Nov. 12.
Woodall-Duckham Continuous Carbonizing System at the Smethwick Corporation Gas-Works.* (66) Nov. 12.
The Radiation from Flames and the Welsbach Mantle.* E. J. Evans. (Paper read before the Manchester and District Junior Gas Assoc.) (66) Nov. 12.
The Grant Automatic Screw Machine.* (72) Nov. 14.
The Manufacture of Chains.* James H. Baker. (72) Nov. 14.
Oil Cooling Plant for Hardening Room.* (72) Nov. 14.
The Utilization of Blast-Furnace and Coke-Oven Gases. M. A. Gouvy. (Paper read before the Société de l'Industrie Minérale.) (11) Nov. 15.
Principles of Incandescent Gas Lighting.* R. F. Pierce. (83) Nov. 15.
Determination of Heating Value of Solid Fuels by Calculation from the Proximate Analysis. Horace H. Clark. (83) Nov. 15.
The Design of Motor Vehicles. H. E. Wimperis. (12) Nov. 15.
Recent Developments in Fire Bricks.* F. T. Havard. (76) Nov. 15.
The Effect of Cold Weather on the Gas Industry. C. W. Andrews. (Paper read before the Am. Gas Inst.) (24) Nov. 18.

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A System of Gas Engine Governing.* George S. Cooper. (Paper read before the Ohio Soc. of Mech., Elec. and Steam Engrs.) (62) Nov. 18.
The New Gas-Works at Linden (Hanover). William Anderson. (Paper read before the Assoc. of Gas Engrs.) (66) Nov. 19.
Retort-House Furnace Charging and Other Details.* G. M. Gill. (Paper read before the Southern Dist. Assoc. of Gas Engrs. and Managers.) (66) Nov. 19.
Pipe Jointing, and a Few Notes on Main Laying.* George Head. (Paper read before the Southern Dist. Assoc. of Gas Engrs. and Managers.) (66) Nov. 19.
High-Pressure Gas.* F. W. Burstall. (Paper read before the Midland Junior Gas Assoc.) (66) Nov. 19.
Some Notes on Oxide Purification.* C. V. Townsend. (Paper read before the Yorkshire Junior Gas Assoc.) (66) Nov. 19.
Analysis of Water-Gas Purification Material. E. C. Uhlig. (Abstract of paper read before the Am. Gas Inst.) (66) Nov. 19.
High Vacuum with Surface Condensers. P. E. Reynolds. (64) Nov. 19.
Making the New York Air Brake.* Fred H. Colvin. (72) Serial beginning Nov. 21.
Foundry Heating and Ventilation.* W. H. Carrier. (Paper read before the Am. Foundrymen's Assoc.) (20) Nov. 21.
The Utilization of Peat Fuel. H. Poynter Bell. (96) Nov. 21.
China Clay Production in Devon and Cornwall, England. W. S. Harvey, A. M. Can. Soc. C. E. (96) Nov. 21.
The Coking of Coal at Low Temperatures. S. W. Parr and H. L. Olin. (Abstract from *Bulletin* No. 60, Univ. of Illinois Eng. Experiment Station.) (57) Nov. 22; (62) Nov. 11.
Air Compressors. George Barr. (Paper read before the Manchester Assoc. of Engrs.) (47) Nov. 22.
The Modern Gas-Engine. A. Vennell Coster. (Abstract of paper read before the Nottingham Eng. Soc.) (11) Nov. 22.
Mechanical Handling of Package Freight at Steamship Terminals.* (18) Nov. 23.
General Description of the First Gas Oven Plant Erected in this Country.* (24) Nov. 25.
The Venturi Gas Meter.* (24) Nov. 25.
Effect of Various Diluents on the Candle Power of Oil Gas. Arthur H. Elliott. (Paper read before the Am. Gas Inst.) (24) Nov. 25.
The Legal Specifications for Illuminating Gas. E. B. Rosa and R. S. McBride. (Paper read before the Am. Gas Inst.) (24) Nov. 25.
Power Plant of the Charlton Mills.* Warren O. Rogers. (64) Nov. 26.
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A Large Machine Plant in Colorado.* F. A. Stanley. (72) Nov. 28.
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Steam Meters.* J. A. Knesche. (9) Serial beginning Dec.
Utilization of Gas Appliances. Wm. J. Serrill. (Paper read before the Am. Gas Inst.) (83) Serial beginning Dec. 2.
Utilization and Value of By-Products in Gas Production.* (83) Dec. 2.
Gas Lighting *versus* Electrical Lighting for Public Streets of Large Towns. (24) Dec. 2.
The Evolution of the American Incandescent Inverted Gas Burner.* Thomas J. Little, Jr. (24) Dec. 2.
Report of Committee on Small Gas Engines. (Paper read before the Am. Gas Inst.) (24) Dec. 2.
Power Costs in a Manufacturing Plant.* H. J. Mistele. (64) Dec. 3.
Gas Engines at the Central Furnaces.* A. D. Williams. (64) Dec. 3.
Moteurs Mixtes à Explosion ou à Combustion et à Air Comprimé; Démarrage Automatique et Surcharge des Moteurs.* L. Letombe. (32) Sept.
De la Sécurité en Aéroplane; Stabilité, Relations de la Stabilité et de la Sécurité. Lucas Girardville. (32) Sept.
Mesure de la Consommation de Charbon des Fours Rotatifs à l'Aide de l'Analyse des Fumées. (84) Oct.
Etude du Mouvement d'une Bielle, Application à la Détermination des Forces d'Inertie. P. Massot. (37) Oct. 31.
Production et Distribution du Gaz d'Huile dans les Principales Gares de Berlin.* (33) Nov. 9.
Le IV^e Salon de la Locomotion Aérienne, à Paris (27 octobre-10 novembre 1912).* G. Espitallier. (33) Serial beginning Nov. 9.
Grundlagen für die Untersuchung von Zweitaktmaschinen.* P. Meyer. (48) Oct. 5.
Neuere Kranbauarten für Sonderzwecke.* C. Michenfelder. (48) Oct. 12.
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Neuere Baggerkonstruktionen.* Paulmann und Blaum. (48) Oct. 19.
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Die Erzeugung "umgekehrten Hartgusses" und die Härtung von Gussstücken durch Gebläseluft.* Bernhard Osann. (50) Oct. 31.
Die Ursachen der Lunkerung und ihr Zusammenhang mit Schwindung und Gattierung.* A. Diefenthäler. (50) Oct. 31.
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Elektrisch betriebenes Panzerplattenwalzwerk in Witkowitz.* J. Gutmann. (50) Nov. 14.
Die Berechnung der Wirtschaftlichkeit elektrischer Hauptschachtfördermaschinen. W. Philippi. (41) Nov. 21.

Metallurgical.

The Bessemer Process of Steel Making.* H. C. Williamson. (108) Nov.
The Bishop Creek Mill.* Algernon Del Mar. (103) Nov. 2.
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Work of the Cananea Copper Company.* L. D. Ricketts. (103) Nov. 2.
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Fink Smelting Furnace for Copper, Lead and Zinc.* Edward Fink. (82) Nov. 2.
The Flotation Process at the Kyloe Copper Mine, N. S. W. J. W. Ashcroft. (Abstract of paper read before the Institution of Min. and Metal.) (68) Nov. 2.
The Siemens Regenerative Gas-Fired "Push" Furnace for Reheating Ingots, Blooms and Billets.* Frederick Siemens. (22) Nov. 8.
Electro-Deposition of Metals and Alloys.* Geo. P. Lee. (Paper read before the Inst. of Marine Engrs.) (22) Nov. 8.
Electric Iron-Smelting at Trollhättan. (11) Nov. 8.
The American Zinc Smelter at Hillsboro, Illinois.* Carpel L. Breger. (82) Nov. 9.
New Volumetric Methods in Vogue at Mints. Harold French. (82) Nov. 9.
Development of the Reverberatory Copper Smelting Furnace.* E. P. Mathewson. (Paper read before the Internat. Congress of Applied Chemistry.) (103) Nov. 9.
Separation of Base Metals in Cyanide Solution for Quantitative Determination. P. L. Guppy and Douglas Waterman. (103) Nov. 9.
Cyanide Plant at Empire Mines, Grass Valley.* Frank A. Vestal. (103) Nov. 9.
Microscopical Analysis of Steel Sheets.* C. Arthur White. (Paper read before the Am. Iron and Steel Inst.) (20) Nov. 14; (101) Nov. 15.
Huntington Mill Practice at Kalgoorlie.* M. W. von Bernewitz. (103) Nov. 16.
Milling Plants of the Oriental Consolidated, Unsan, Korea.* A. E. Drucker. (103) Nov. 23.
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Sur les Alliages du Platine avec l'Aluminium.* Chouriguine. (93) Nov.
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Address at the 44th Annual Convention, Seattle, Washington, June 25th, 1912. John A. Ockerson, President, Am. Soc. C. E. (54) Vol. 75.
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Die weitere Entwicklung der Selbstverwaltung auf dem Gebiete des Wegenwesens nach Inkrafttreten der Dotationsgesetze vom 8 Juli 1875 (Gesetzsamml. S. 497) und vom 2 Juni 1902 (Gesetzsamml. S. 167) in der Zeit vom 1. April 1905 bis dahin 1910. (40) Apr. 3.
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Facts and Fancy About Ventilation. Leonard Hill. (From *Nature.*) (19) Serial beginning Nov. 30.
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Certain Legal Aspects of Water-Power Development in Maine. Cyrus C. Babb, M. Am. Soc. C. E. **(28)** Sept.
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Maintaining Irrigation Canals Subject to Heavy Deposits of Silt, Special Machinery and Methods Employed in the Imperial Valley, California.* J. C. Allison. (14) Nov. 16.
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PROCEEDINGS

OF THE

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

(INSTITUTED 1852)

VOL. XXXVIII.

JANUARY TO DECEMBER, 1912.

NEW YORK:
PUBLISHED BY THE SOCIETY

1912.

Entered according to Act of Congress, by the AMERICAN SOCIETY OF CIVIL ENGINEERS, in the Office of the Librarian of Congress at Washington.

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Vol. XXXVIII. DECEMBER, 1912. No. 10.

AMERICAN SOCIETY OF CIVIL ENGINEERS

INSTITUTED 1852

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Vol. XXXVIII. DECEMBER, 1912. No. 10.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

CHARACTERISTICS OF CUP AND SCREW CURRENT METERS PERFORMANCE OF THESE METERS IN TAIL-RACES AND LARGE MOUNTAIN STREAMS STATISTICAL SYNTHESIS OF DISCHARGE CURVES.

By B. F. Groat, Assoc. M. Am. Soc. C. E.

To be Presented February 5th, 1913.

During the summer and autumn of 1912 the writer ran a number of efficiency tests on two of the 6 000-h.p. hydraulic turbine units recently installed in the power-house of the St. Lawrence River Power Company, at Massena, N. Y. On one of the units, two sets of tests were run, one prior, and one subsequent, to cutting off several feet of the draft-tubes. On the other unit, one set of tests was run after the draft-tubes had been shortened, as had been done in the case of the other turbine unit.

In all, some 40 000 instrumental readings, including gauge readings, were made. Of these, 7 000 were complete velocity observations by current meters, while 4 000 additional readings on a Pitot tube furnished about 100 complete velocity observations for comparison with simultaneous readings by the current meters.

Owing to the nature of the tail-races, which discharge into the Grasse River, a weir test was out of the question. Before beginning

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Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

the tests, therefore, it became necessary to decide between the current meter and Pitot tube as instruments for measuring the flow.

In favor of the current meter is its simplicity and the facility with which it may be used in tail-races. Against it is the fact that, notwithstanding the large number of observers who have experimented with it and the large number of records which have been made by it, there is still a great deal of well-founded skeptical discussion as to the accuracy of the instrument when the records are based solely on the still-water rating.

The Pitot tube has been not only a subject of adverse criticism but also an instrument about which much positive ignorance seems to exist. It would seem, however, that the recent demonstrations of the accuracy of Darcy and Bazin's experiments, 1865, by Messrs. William Monroe White,* L. F. Moody, Gardner S. Williams, John R. Freeman, and others, should sufficiently dispel all doubts as to the reliability of the instrument. On the other hand, where the velocity of the water is variable from moment to moment, a large number of readings must be taken and reduced to a mean square root in order to obtain sufficiently close approximations to the average in any one velocity determination.

After a final summary of advantages and disadvantages, it was decided to use both the screw and cup types of current meter, and to check their records, if necessary, with a Pitot tube.

E. E. Haskell, M. Am. Soc. C. E., Director of the College of Civil Engineering, Cornell University, made up one of his screw type meters especially for the series of tests to be undertaken, and a new Gurley-Price meter of the cup type (No. 600) was purchased from the makers at Troy. Master Mechanic D. J. Jones, of the Power Company, made up a Pitot tube, following as nearly as possible the description of Tube *N* given in Mr. White's paper, mentioned above.

The following are the general conclusions concerning current meters which have been drawn from the tests with the foregoing equipment:

1.—†When a cup meter is run in perturbed water it will register

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* "The Pitot Tube; Its Formula," by William Monroe White, *Journal*, Association of Engineering Societies, Vol. XXVII, 1901, p. 35.

† In a discussion of a paper on current meter and weir discharge comparisons by Edward C. Murphy, Assoc. M. Am. Soc. C. E., *Transactions*, Am. Soc. C. E., Vol. XLVII, 1902, p. 370, Charles H. Miller, M. Am. Soc. C. E., describes certain experiments on screw and cup meters in the following language:

"The Haskell meter was lowered from one side of the skiff and one of the Price meters a larger number of revolutions per second than a perfect still-water rating would indicate.

2.—†When a screw meter is run in perturbed water it will register a smaller number of revolutions per second than a perfect still-water rating would indicate.

3.—†In the foregoing sense, a cup meter is affected relatively to a much greater extent than a screw meter. In the tail-races at Massena, as an average, the cup meter was affected to the extent of 6%, while the Haskell meter was affected mostly by less than 1 per cent. In boilers of considerable violence the cup meter may easily over-register by 25%, while the screw meter will under-register by not more than 3 or 4 per cent.

4.—Either type of meter when run in perturbed water will give uniform records in equal times provided these times are sufficiently long, the flow of the water itself being subject to an established regimen.

5.—If both types of meter are used simultaneously in perturbed water, the disparity between the discrepant velocities thus determined by the still-water rating may be taken as a basis for correcting the discrepant velocities.

6.—The average corrections thus obtained for the Haskell meter when run with the Gurley-Price meter in the tail-races at Massena varied from 0.5 to 0.9 of 1%, while the corresponding corrections for the Gurley-Price meter were about six times larger. Comparisons with the Pitot tube furnished substantially the same corrections as those obtained by comparison of the meters.

7.—It would seem to follow that current-meter observations based on still-water ratings without further correction should be made with great caution. On the other hand, it seems certain that the correction

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from the other side, both to the same depth (about 5 ft.). The registrations or revolutions of each, for periods of from 5 to 10 minutes, were noted; then, for similar periods of time, the skiff was caused to rock from one side to the other at short intervals, and the registrations recorded, the movement of the skiff giving to the meters a vertical motion of from 1 to 2 ft. Under this motion the revolutions of the Price meter increased, while those of the Haskell meter decreased, but in a less proportion than the increase of the Price meter, showing that the error due to instability of support is greater in the Price than in the Haskell meter. Lack of time prevented more extended observations, and in different velocities of current, which probably would have evolved some fixed difference due to the different construction of the meters in question."

Conclusions 1, 2, and 3, of the present paper seem to have been fairly stated by Mr. Miller, but as applied only to instability of support. They are here advanced as inherent characteristics of these different types of meter, and extended to apply, not only to cases of instability of support, but also to these current meters generally, however supported, in flowing water.

for a cup meter when run at a good meter station on an open river is not large, while the corresponding correction for a screw meter may be negligible.

Plate CXXXIV shows the results of a number of ratings of the Haskell meter. The general method was similar to that adopted by the United States Lake Survey, as described in the reports by F. C. Shenehon, M. Am. Soc. C. E.,* covering his current-meter observations. The meter was suspended by either cable or rod from a bowsprit at the head of a light skiff. The skiff, with an observer, was then towed back and forth over a 200-ft. base at a given velocity, one such double run constituting a velocity observation. The total time and total number of revolutions then stand for the transit of a 400-ft. base in perfectly still water.

The first four ratings, on June 29th and 30th, 1911, were made along the longitudinal center line of Lock No. 15 in the old Cornwall Canal, at Cornwall, Ont. Both lock gates were open, but the north miter leaf of the lower gate, opening into the St. Lawrence River, was not fully into its recess in the north wall. The meter was about 4 ft. below the surface of the water and the depth in the lock was 9 or 10 ft. The water in the lock had a tendency to surge at times. Sometimes there was considerable velocity through the lock, and at other times very little.

The ratings of August 12th and October 3d, 1911, were made in a bay of the Grasse River, opposite the power-house of the St. Lawrence River Power Company, at Massena, N. Y. The meter was about 2.25 ft. below the surface of the water, and the average depth under the base line was about 7 ft., with a shallow spot near the east end about 5 ft. deep. There was very little current, but at times there were surges due to the operation of the power-house just across the river.

The ratings of July, 1912, were made under the direction of Professor Arthur M. Greene, Jr., at the rating station of Rensselaer Polytechnic Institute, Troy, N. Y., after the meter had been used extensively at Massena and in North Carolina and Tennessee. The meter had been overhauled twice at Cornell University before these ratings, but long after those at Massena. The meter was also provided with a new shaft. After running a complete set of tests at Troy, the new shaft was put in and another set of tests was made.

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* As described in Reports, Chief of Engineers, U. S. Army, 1900 to 1904, inclusive.

PLATE CXXXIV.
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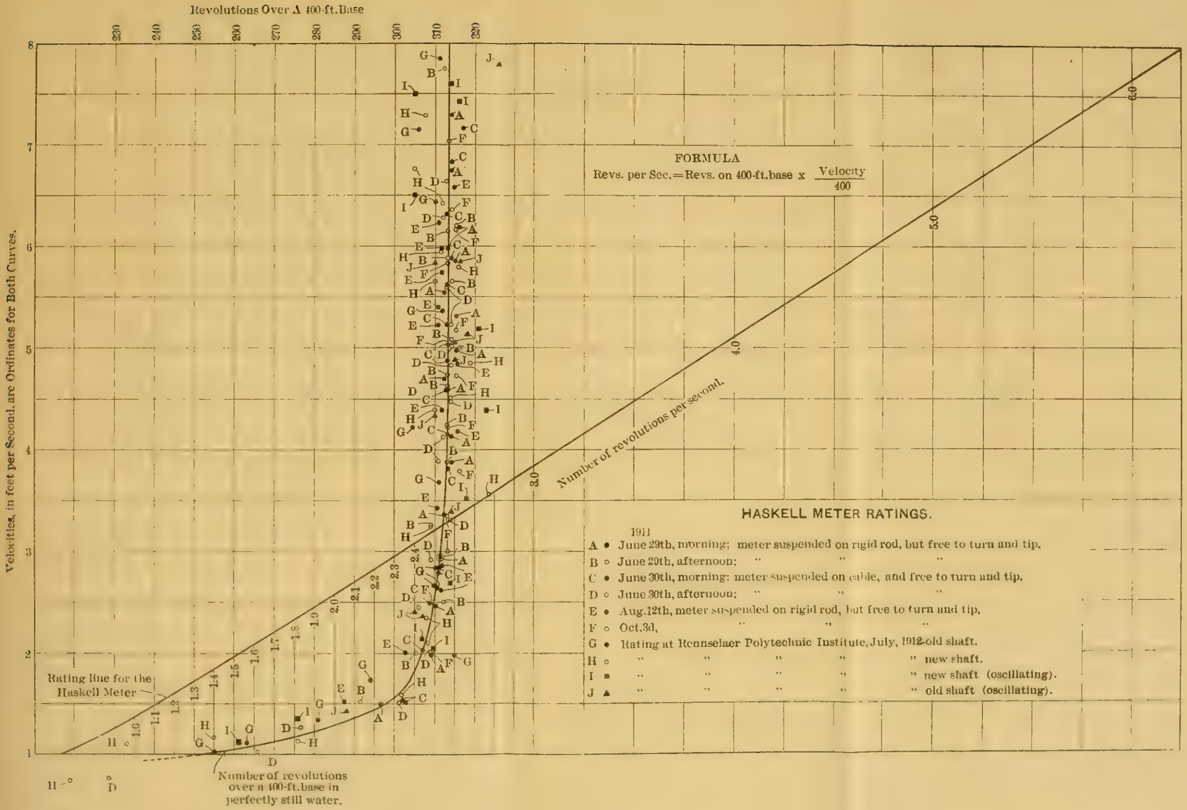
GROAT ON
CUP AND SCREW CURRENT METERS.



The curve of revolutions over a 400-ft. base was plotted from the first four ratings in the Cornwall Canal. It will be seen from Plate CXXXIV, however, that the subsequent ratings do not materially alter the position of this line, up to velocities of 5 or 6 ft. per sec. If the correction were made, the number of revolutions, as shown by the line, would be increased only ¼% at 4 ft. per sec., and reduced only ½% at about 8 ft. per sec. In fact, it may be seen that, out of about 100 double runs in the canal lock and Grasse River, not one plotted point differs by more than 1% from the line of revolutions as determined from the first four ratings for velocities of more than 1½ ft. per sec. For velocities of less than 1½ ft. per sec. the line of revolutions is so steep that errors of somewhat larger magnitude are to be expected. In the oscillating tests, the meter was oscillated parallel to the motion of the car, and covered an amplitude of 5¾ in. for every 8-ft. advance of the car. Transverse oscillations reduce the number of revolutions over a given base. The relations between velocity and revolutions over a 400-ft. base were then plotted, as shown on Plate CXXXIV, and from the resulting curve the rating line for still water was located and drawn, also as shown on that plate.

After having drawn the rate line, a reduction diagram, Plate CXXXV, may be prepared, from which velocities may be read directly when referred to time and revolutions. This obviates either the necessity for reducing revolutions to revolutions per second, or of taking a fixed time for observing velocities, which is inexpedient where velocities are variant.

Plate CXXXVI shows the Gurley-Price meter rating curves, obtained in a manner precisely similar to that used for the Haskell meter. In fact, the ratings were frequently made on the same day as for the Haskell meter.

In order that there may be no misunderstanding concerning these ratings, it may be stated that the tests were severe, when considered as a whole. Some of the ratings were made at a depth of 4 ft., some at a depth of 2 ft. 3 in., some in windy weather, some in calm weather, and several different observers acted at different times.

Under all these diverse conditions it may be seen that the Haskell meter, in the Massena and Cornwall ratings, never varied by more than 1% in any individual observation, and that rating lines drawn for different ratings would differ by only 0.2 or 0.3 of 1% at the greatest.

The Gurley-Price meter exhibits a much greater range of variations, 5 or 6% up to velocities of 5 ft. per sec., which were considerably in excess of the mean velocities in the tail-races where the meter was used.

It is not contended here that a satisfactory still-water rating under perfect conditions cannot be obtained with a meter of this type; it is intended, however, to show that varying conditions of water produce relatively larger variations in the records of the cup meter than in those of the screw meter.

On comparing the maker's rating curve with the several ratings in the canal and in the bay of Grasse River, it will be seen that the number of revolutions of the Gurley-Price meter over a 400-ft. base is generally higher in the canal and bay than in the maker's rating. Hence it is fair to suspect that a perfect still-water rating line of a cup meter is a line of minimum number of revolutions for such a meter, and that, when the water is disturbed in any degree, the number of revolutions over a fixed base will always be increased, other things being equal.*

Similarly, the contrary suspicion may be entertained, that a perfect still-water rating line of a screw meter is a line of maximum number of revolutions for such a meter, and that, when the water is disturbed in any degree, the number of revolutions over a fixed base will always be decreased, other things being equal.

Since, under similar circumstances, the deviations of the Gurley-Price meter are about six times as large as those of the Haskell meter, but in the contrary sense, it would seem fair to conclude that when the meters are run simultaneously in flowing water, one-seventh of any difference in the velocities thus determined from the still-water ratings should be attributed to a deviation of the Haskell meter, while six-sevenths should be attributed to a simultaneous deviation of the Gurley-Price meter.

Thus, if the difference between the velocities determined by the Haskell and Gurley-Price meters should be 0.42 ft. per sec., 0.06 ft. per sec. should be added to the record of the Haskell meter, while 0.36 ft. per sec. should be deducted from the corresponding record of the Gurley-Price meter. In strictness, this correction should be

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* Certain interesting experiments by Professor L. F. Moody, in the rating station at Rensselaer Polytechnic Institute, seem to agree with the writer's experiments on this point and confirm the general conclusion.

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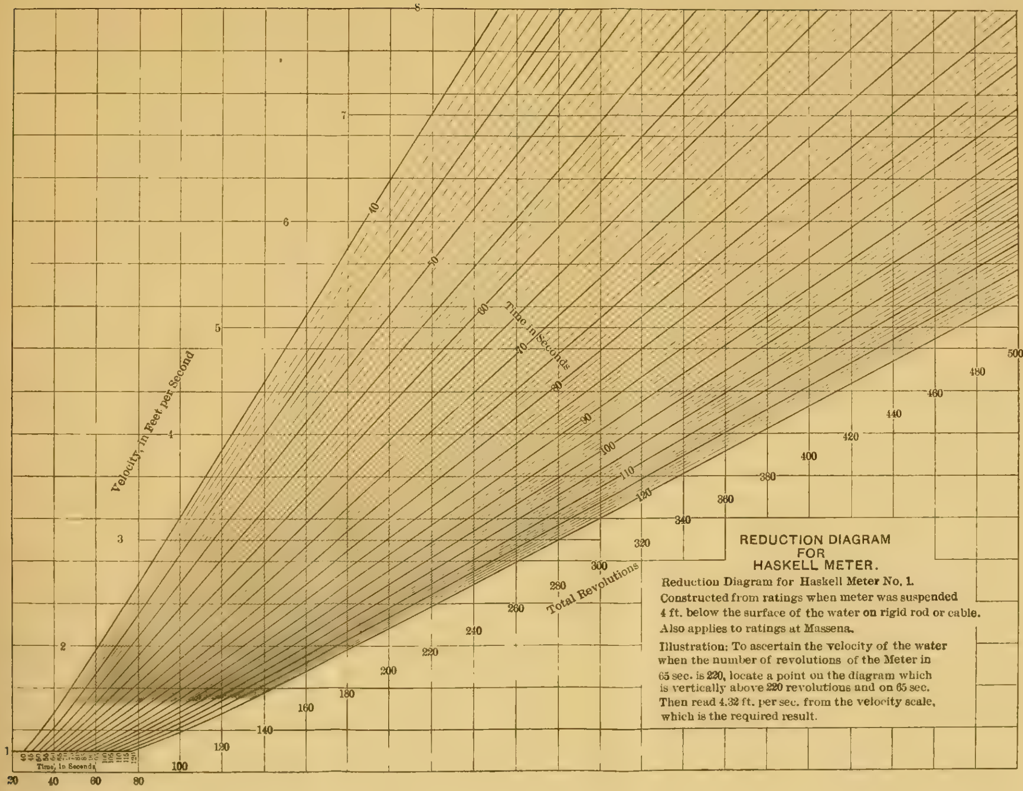

REDUCTION DIAGRAM
FOR
HASKELL METER.

Reduction Diagram for Haskell Meter No. 1.
Constructed from ratings when meter was suspended 4 ft. below the surface of the water on rigid rod or cable.
Also applies to ratings at Massena.

Illustration: To ascertain the velocity of the water when the number of revolutions of the Meter in 65 sec. is 220, locate a point on the diagram which is vertically above 220 revolutions and on 65 sec. Then read 4.32 ft. per sec. from the velocity scale, which is the required result.

applied to revolutions per second, but, as the number of revolutions is so nearly proportional to the velocity, and as the corrections are relatively small, no serious error results. The particular ratio here determined, of course, applies only to the two individual meters as used in the tail-races at Massena by the writer.

In order to establish more satisfactorily the principle mentioned above, the boat was rocked during several of the runs of a rating, imparting to the meter which was being rated an oscillation in an arc about 3 ft. long and about 2½ ft. in radius, and at right angles to the direction in which the meter was being drawn through the water. The result was that the Gurley meter was found to increase its number of revolutions by 15% while the Haskell meter reduced its number of revolutions by 2½%, practically the same ratio as that deduced above from the rating curves. The effect of longitudinal oscillations was tested also. The result of special tests of this character at Rensselaer Polytechnic Institute, may be seen on Plate CXXXIV. Subsequently, other tests on a new Haskell meter showed that longitudinal oscillations of 22 in. in 6 ft. advance of car retarded the meter slightly, up to velocities of about 2 ft. per sec., above which the meter is accelerated, the error being less than 2% at 9 ft. per sec. The net result in perturbed water, however, seems to be slight retardation in all cases.

It is now desirable to show how these principles have been used to correct the current meter records actually observed in the tail-races during the turbine tests referred to at the outset. In order to do this properly, it will be necessary to state another conclusion, based on the current meter records, which the writer hopes to take up more fully in the future under another title. The conclusion is as follows:

Under an established regimen, the distribution of the flow of water in a tail-race obstructed by stilling racks is fixed in character, the ratio of the average velocity at any given point to that at any other given point in the race being constant. This proposition applies over a considerable range in the total amount of discharge, but supposes the actual wetted cross-section of the race to remain the same.

The foregoing proposition was proven from a number of the turbine tests by computing and compiling the relative velocities at the 84 meter points in the races where velocity observations were taken. A turbine unit discharged through two tail-races, each about 15 ft.

wide, while the depth of the water varied from 15 to 16 ft. The meter section of each race was divided into six equal vertical, and seven equal horizontal, strips, and the meter points were the forty-two intersections of the median lines of the strips. The verticals were numbered 1 to 6 from west to east, while the depths were numbered 1 to 7 downward.

To demonstrate the truth of the principle of a fixed distribution of flow in tail-races, and also as a verification of Conclusion No. 4, Tables 1 to 4 are given:

TABLE 1.—GURLEY-PRICE METER IN WEST RACE, SHOWING CONSTANCY OF VELOCITIES TAKEN IN QUICK SUCCESSION. VELOCITIES WERE OBSERVED WITH A SINGLE STOP-WATCH PROVIDED WITH TWO SECOND HANDS.

Test of September 9th, at 0.82 gate.
The numbers are of revolutions per second.

Depths.	Verticals.						Totals of lower set.
	1	2	3	4	5	6	
1	1.32	1.40	1.12	0.88	0.90	0.94	6.62
	1.36	1.42	1.16	0.89	0.87	0.92	
2	1.23	1.44	1.40	1.23	1.20	1.16	7.70
	1.24	1.44	1.40	1.24	1.22	1.16	
3	1.35	1.44	1.62	1.42	1.34	1.31	8.45
	1.35	1.44	1.59	1.41	1.35	1.31	
4	1.37	1.44	1.43	1.30	1.31	1.37	8.21
	1.36	1.44	1.43	1.30	1.32	1.36	
5	1.53	1.47	1.52	1.40	1.26	1.38	8.57
	1.49	1.48	1.53	1.42	1.27	1.38	
6	1.70	1.72	1.80	1.72	1.51	1.66	10.09
	1.69	1.72	1.80	1.72	1.50	1.66	
7	1.60	1.81	1.84	1.78	1.78	1.86	10.64
	1.58	1.80	1.84	1.78	1.79	1.85	
Totals of lower set.	10.07	10.74	10.75	9.76	9.32	9.64	60.28

The register was started first and the observer noted the pointer as it clicked from revolution to revolution of the meter. By synchronizing with the rythm of the register, it was possible for the observer to start the stop-watch almost exactly at the moment the register clicked to zero. Similarly, the primary second hand could be stopped after any desired number of revolutions while the secondary hand could be stopped at, say, twice that number. Thus two or more velocities in immediate succession could be determined for each meter point in the tail-races.

In support of the principle of fixed distribution, it may be stated that the percentages corresponding to the figures of Tables 1 and 2 at the 84 meter points agree remarkably well with the corresponding ones of Tables 3 and 4 after applying certain necessary small corrections. Tables 1 and 2 each represent an individual set of double discharge measurements in one of the races, while Tables 3 and 4 have

PLATE CXXXVI.
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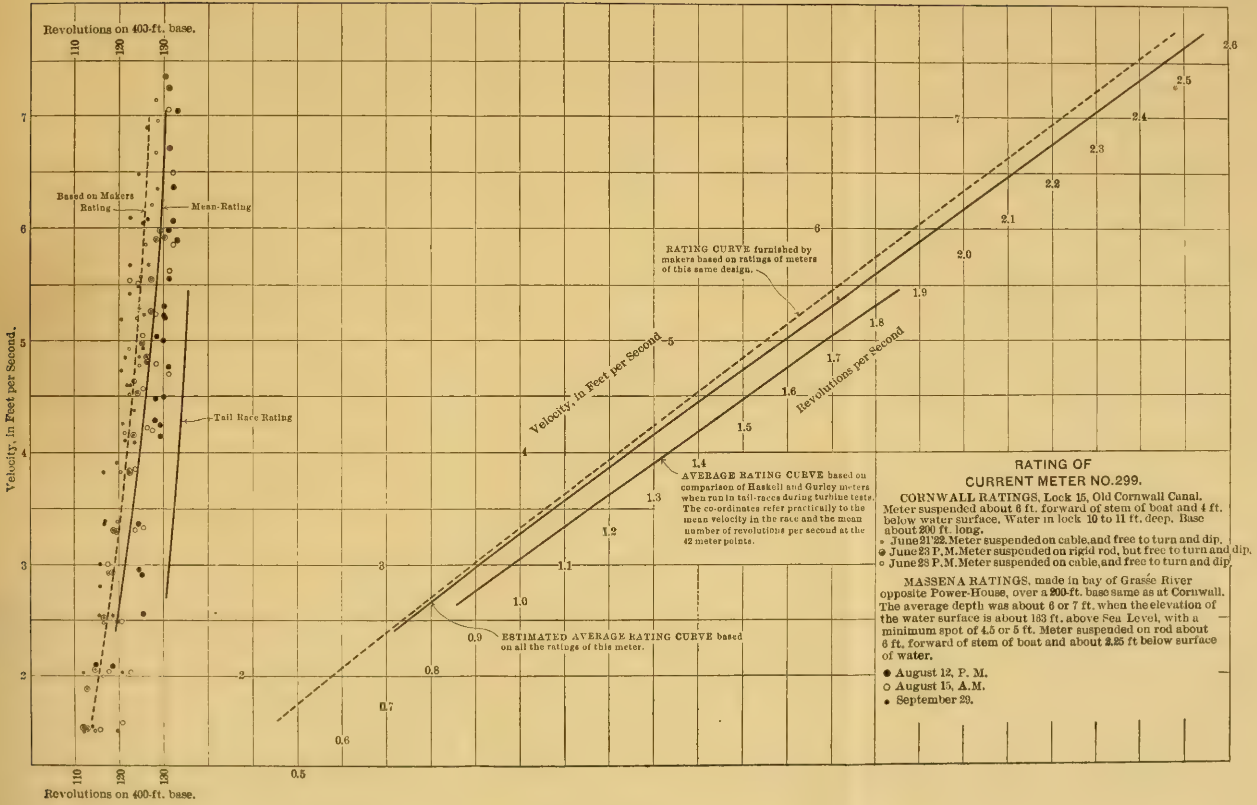


RATING OF
CURRENT METER NO. 299.

CORNWALL RATINGS, Lock 15, Old Cornwall Canal. Meter suspended about 6 ft. forward of stem of boat and 4 ft. below water surface. Water in lock 10 to 11 ft. deep. Base about 200 ft. long.

- June 21'22. Meter suspended on cable, and free to turn and dip.
- ◉ June 23 P. M. Meter suspended on rigid rod, but free to turn and dip.
- ○ June 23 P. M. Meter suspended on cable, and free to turn and dip.

MASSENA RATINGS, made in bay of Grasse River opposite Power-House, over a 200-ft. base same as at Cornwall. The average depth was about 6 or 7 ft. when the elevation of the water surface is about 163 ft. above Sea Level, with a minimum spot of 4.5 or 5 ft. Meter suspended on rod about 6 ft. forward of stem of boat and about 2.25 ft below surface of water.

- ● August 12, P. M.
- ○ August 15, A.M.
- • September 29.

TABLE 2.—HASKELL METER IN EAST RACE, SHOWING CONSTANCY OF VELOCITIES TAKEN IN QUICK SUCCESSION. THE COMPARISONS ARE NOT AS GOOD AS WITH THE GURLEY-PRICE METER, BECAUSE THE VELOCITIES WERE TAKEN WITH TWO DIFFERENT WATCHES, ONE OF WHICH WAS NOT VERY RELIABLE.

Test of September 9th, at 0.82 gate.
The numbers are of feet per second.

Depths.	Verticals.						Totals of lower set.
	1	2	3	4	5	6	
1	3.23 3.12	2.74 2.75	2.48 2.50	2.41 2.39	2.94 2.97	3.75 3.72	17.45
2	3.62 3.67	.... 3.49	.... 3.26	.... 3.27	.... 3.79	.... 4.01	21.49
3	4.12 4.22	3.96 3.98	3.53 3.79	3.91 3.98	4.13 4.17	4.09 4.10	24.24
4	4.21 4.23	3.92 3.95	3.64 3.64	3.73 3.70	3.88 3.91	4.07 4.05	23.48
5	4.30 4.35	3.90 3.94	3.73 3.73	3.68 3.63	3.61 3.64	4.25 4.28	23.57
6	4.77 4.80	4.25 4.31	4.74 4.75	4.61 4.68	4.18 4.22	4.44 4.49	27.25
7	5.07 5.12	5.27 5.27	5.32 5.35	5.05 5.01	4.98 4.99	4.61 4.58	30.32
Totals of lower set.	29.51	27.69	27.02	26.66	27.69	29.23	167.80

The two velocities at each meter point were taken in immediate succession in a manner similar to that described in the foot note under Table 1, except that two stop-watches were used. The observations were about 1 min. in duration for the first velocity and twice as long for the second velocity.

TABLE 3.—RELATIVE DISTRIBUTION OF FLOW IN WEST RACE OF UNIT No. 3 DURING TESTS OF JULY AND AUGUST. WATER SURFACE AT ELEVATION 162.85.

Depths.	Verticals.						Totals.
	1	2	3	4	5	6	
1	2.16	2.18	1.84	1.53	1.50	1.97	11.18
2	2.11	2.41	2.32	2.07	2.02	2.22	13.15
3	2.04	2.37	2.46	2.31	2.18	2.14	13.50
4	2.13	2.29	2.34	2.20	2.26	2.36	13.58
5	2.19	2.41	2.57	2.29	2.27	2.67	14.40
6	2.65	2.87	3.00	2.85	2.42	2.68	16.47
7	2.72	2.87	3.00	3.06	3.03	3.02	17.70
Totals	16.00	17.40	17.53	16.31	15.68	17.06	99.98

The numbers are percentages of the sum of the velocities at the 42 meter points in the race. Thus, in Vertical 1, Depth 1, the velocity is 2.16% of the sum of all the velocities at the meter points.

TABLE 4.—RELATIVE DISTRIBUTION OF FLOW IN EAST RACE OF UNIT NO. 3 DURING TESTS OF JULY AND AUGUST. WATER SURFACE AT ELEVATION 162.85.

Depths.	Verticals.						Totals.
	1	2	3	4	5	6	
1	1.72	1.69	1.66	1.85	2.16	2.24	11.30
2	2.02	2.04	2.00	2.15	2.24	2.24	12.70
3	2.42	2.31	2.19	2.20	2.31	2.29	13.70
4	2.62	2.54	2.26	2.12	2.17	2.45	14.20
5	2.59	2.41	2.18	2.16	2.13	2.43	13.90
6	2.73	2.49	2.80	2.82	2.59	2.72	16.20
7	3.00	3.04	3.11	3.02	2.97	2.88	18.00
Totals	17.12	16.55	16.21	16.33	16.57	17.22	100.00

The percentages of Tables 3 and 4 are computed by dividing the velocity at any meter point by the sum of the velocities at all the meter points.

been compiled as average percentages from a number of such sets of observations.

In verification of Conclusion No. 4, it may be seen that each pair of velocities determined at the same point by either meter consists practically of two equal velocities. This truth has been found to apply throughout the turbine tests.

Attention should be directed to the fact that while water discharged from a turbine will be much quieted by stilling racks, yet the latter themselves are sources of disturbance, and that the violent agitation caused by the turbines is merely supplanted by an entirely different type of disturbance produced by the racks. The effect of the racks is to render the flow parallel to the side-walls of the race, but the body of the water is full of small eddies and boilers of more or less violence. The parallelism of flow at each meter point was tested by a kind of inverted weather vane, which the writer understands was first used by John R. Freeman, M. Am. Soc. C. E. The indications of parallelism of flow by this vane were extremely satisfactory at all points.

The meter section was about 30 ft. down stream from the racks. The effect of the disturbance from the racks, however, was plainly indicated by the divergence of the velocity records, based on the still-water ratings, when the two meters were run in quick succession at any meter point. It is well to note here that the velocity was greater near the bottom of the race than at the top, and that the agitation by the racks was greater near the top than at the bottom, where the flow was extremely steady and subject to little or no agitation. This is clearly shown by the records, and especially by the fact that the clicking of the register was almost absolutely uniform when the meters were near the bottom. It is also shown by the fact that there was always a greater disparity between the meter records near the surface than at the bottom.

To be precise, the corrections for the meters should be computed for each of the 84 meter points in the races. Practically, the corrections may be made for the average velocities in the seven horizontals, because the velocities along any horizontal do not vary widely.

An example of the computation of corrections for the Haskell and Gurley-Price meters is given in Table 5.

TABLE 5.—Computation of Velocity Corrections.

Horizontal in which meter was run.	Velocities Based on the Still-Water Ratings.		Difference.	One seventh of difference + Haskell = true velocity.	Velocity excessive by Gurley. Percentage.	Velocity deficient by Haskell. Percentage.
	Gurley.	Haskell.				
1..........	3.94	3.36	0.58	3.44	14.5	2.4
2..........	4.46	3.90	0.56	3.98	12.0	2.0
3..........	4.74	4.44	0.30	4.48	5.8	0.96
4..........	4.85	4.62	0.23	4.65	4.3	0.72
5..........	5.08	4.89	0.19	4.92	3.2	0.55
6..........	5.68	5.55	0.13	5.57	2.0	0.34
7..........	6.32	6.15	0.17	6.17	2.3	0.38
Totals...	35.07	32.91	2.16	33.21		

$$\text{Average error of Gurley meter} = \frac{6}{7} \times \frac{2.16}{33.21} = 5.6 \text{ per cent.}$$

$$\text{Average error of Haskell meter} = \frac{1}{7} \times \frac{2.16}{33.21} = 0.93 \text{ `` ``}$$

The method given in Table 5 for computing the corrections for the velocities is based solely on the current meter ratings and the rocking experiments in conjunction with the fundamental propositions before stated. It is desirable, therefore, to have independent means of checking the methods and the numerical results.

Accordingly, a Pitot tube was operated at the meter points, in Depths 2, 3, 5, 6, and 7, simultaneously with the Haskell meter. While the meter was recording in Vertical 3 the Pitot was recording in Vertical 2. After the record was taken, both the meter and Pitot were advanced to the next succeeding verticals, so that the meter would then record in Vertical 4 while the Pitot was in Vertical 3. Depths 1 and 4 were omitted because the tail of the Pitot was out of water in Depth 1, and the construction of the piping of the Pitot did not conform with the staging for the observers in such a way as to admit of readings in Depth 4. This might have been remedied, but no great importance was attached to these facts.

The results of these tests are given in Table 6.

It should be noticed in Table 6 that the velocities given in Verticals 1 and 6 were not taken in quick succession. The meter and tube were traversed across each horizontal, beginning with the Pitot tube in Vertical 1 and the meter in Vertical 2, and ending with the Pitot tube in Vertical 5 and the meter in Vertical 6. After the five horizontals were traversed in this manner, the Pitot tube and meter were interchanged in relative position, and readings were taken at the five depths with the Pitot tube in Vertical 6 and the meter in Vertical 1. All other readings by the meter or Pitot tube were followed immediately by a reading of the other instrument.

The writer does not wish to make too much of these Pitot tube tests. The experimenters were not familiar with the instrument, as they had used it on only one other occasion. The dynamic and static columns were drawn up on a scale graduated to single tenths and half tenths of a foot and the differences in head were merely estimated to the nearest hundredth of a foot. This may seem crude, but when it is considered that the water columns are both vibrating, sometimes violently, that twenty or thirty readings are taken for each velocity, and that all percentage errors are nearly split in two by the process of extracting the square root of the head, it will be seen that the method is probably as accurate as need be for the purpose at hand. Indeed, the results seem to justify this conclusion.

Attention may be directed to three general facts shown by the summary of Table 6. The ratios for the verticals increase toward the right in the west race. They increase toward the left in the east race. The ratios for the horizontals increase upward in both races. On the whole, the tendency is for the ratio of the Pitot velocity to the meter velocity to increase upward, as it should, as it has been shown that the meter is retarded toward the surface.

It is not wholly clear to the writer, however, why the Pitot tube

TABLE 6.—COMPARISONS BETWEEN VELOCITIES DETERMINED BY PITOT TUBE AND HASKELL METER AT VARIOUS POINTS IN THE TAIL-RACES OF UNIT NO. 5.

		Verticals.														
Depth.		1		2		3		4		5		6		Totals.		Ratio.
		Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter	
2.........	*A*	....	...	4.06	4.22	3.84	3.29	3.76	3.33	3.86	3.63	....	....	15.52	14.47	1.072
	A	....	....	4.15	4.09	3.86	3.11	3.49	3.28	3.65	3.22	....	....	15.15	13.80	1.098
	B	....	....	3.70	3.31	3.92	3.43	4.19	3.80	4.40	4.40	....	....	16.21	14.97	1.082
	B	....	....	3.84	3.54	3.83	3.77	4.32	4.30	4.40	4.48	....	....	16.39	16.09	1.020
	C	2.56	2.49	2.34	2.34	2.30	2.28	2.08	2.21	2.32	2.17	1.68	1.77	13.28	13.26	1.001
		2.56	2.49	18.09	17.53	17.75	15.88	17.84	17.02	18.63	17.90	1.68	1.77	76.55	72.59	1.055
3.........	*A*	....	....	4.22	4.21	4.14	4.02	4.05	3.98	4.35	4.20	....	....	16.76	16.41	1.020
	A	....	....	4.35	4.19	4.11	4.12	4.15	3.95	4.40	4.20	....	....	17.01	16.46	1.033
	B	....	....	4.06	4.10	4.29	4.44	4.31	4.36	4.46	4.53	....	....	17.12	17.43	0.983
	B	....	....	4.04	4.21	4.37	4.41	4 40	4.35	4.45	4.43	....	....	17.26	17.40	0.991
	C	2.58	2.71	2.36	2.39	2.34	2.41	2.15	2.21	2.36	2.50	2.09	2.06	13.88	14.28	0.972
		2.58	2.71	19.03	19.10	19.25	19.40	19.06	18.85	20.02	19.86	2.09	2.06	82.03	81.98	1.001
5.........	*A*	....	....	5.26	5.41	4.57	4.67	4.37	4.41	4.32	4.32	....	....	18.52	18.81	0.984
	A	....	....	5.27	5.37	4.66	4.89	4 48	4.47	4.33	4.39	....	....	18.74	19.12	0.980
	B	....	....	4.31	4.13	4.02	4.00	4.06	4.10	4.39	4.44	....	....	16.78	16.67	1.006
	B	...	..	4.43	4.14	4.08	3.95	4.11	4.00	4.34	4.33	....	....	16.96	16.42	1.032
	C	2.61	2.69	2.91	2.89	2.48	2.53	2.61	2.64	2.34	2.46	2.16	2.14	15.11	15.35	0.985
		2.61	2.69	22.18	21.94	19.81	20.04	19.63	19.62	19.72	19.94	2.16	2.14	86.11	86.37	0.998
6.........	*A*	....	....	5.36	5.61	5.47	5.55	5.41	5.55	4.93	4.91	....	....	21.17	21.62	0.978
	A	....	....	5.46	5.57	5.47	5.70	5.53	5.62	4.95	5.06	....	....	21.41	21.95	0.976
	C	2.74	2.80	2.98	3.07	3.07	3.10	2.82	2.89	2.60	2.57	2.32	2.17	16.53	16.60	0.996
		2.74	2.80	13.80	14.25	14.01	14.35	13.76	14.06	12.48	12.54	2.32	2.17	59.11	60.17	0.982

REMARKS: *A*—tests in W. race at 0.7 gate; *B* tests in E. race at 0.7 gate; *C*—tests in W. race at 0.37 gate.

TABLE 6.—(*Continued.*)

VERTICALS.

Depth.		1		2		3		4		5		6		TOTALS.		Ratio.
		Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	
7........	*A*	....	....	5.48	5.81	6.05	6.32	6.13	6.19	5.60	5.79	....	....	23.26	24.11	0.965
	A	....	....	5.56	5.79	6.16	6.32	6.21	6.03	5.66	5.79	....	....	23.59	23.93	0.985
	C	3.11	3.07	3.12	3.15	3.28	3.32	3.20	3.16	2.86	2.90	....	....	18.32	18.23	1.005
	C	3.03	3.07	3.06	3.20	3.24	3.33	3.24	3.19	2.99	3.00	2.75	2.63	15.56	15.79	0.985
		6.14	6.14	17.22	17.95	18.73	19.29	18.78	18.57	17.11	17.48	2.75	2.63	80.73	82.06	0.984
Totals..	*A*	....	....	24.38	25.26	24.07	23.85	23.72	23.46	23.06	22.85	....	....	95.23	95.45	0.998
	A	....	....	24.79	25.01	24.26	24.14	23.86	23.45	22.99	22.66	....	....	95.90	95.26	1.008
	B	....	....	12.07	11.57	12.23	11.87	12.56	12.26	13.25	13.37	....	....	50.11	49.07	1.021
	B	....	....	12.31	11.89	12.28	12.13	12.83	12.65	13.19	13.24	....	....	50.61	49.91	1.014
	C	16.63	16.83	16.77	17.04	16.71	16.97	16.10	16.30	15.47	15.60	11.00	10.77	92.68	93.51	0.991
		16.63	16.83	90.32	90.77	89.55	88.96	89.07	88.12	87.96	87.72	11.00	10.77	384.53	383.17	1.004
Ratio...	*A*	......		0.965		1.010		1.010		1.010		......		......		
	A	......		0.990		1.006		1.018		1.013		......		......		
	B	......		1.042		1.030		1.025		0.991		......		......		
	B	......		1.036		1.012		1.015		0.995		......		......		
	C	......		0.985		0.985		0.988		0.993		......		......		
		0.988		0.995		1.007		1.011		1.003		1.021		1.004		

REMARKS: *A*—tests in W. race at 0.7 gate; *B*—tests in E. race at 0.7 gate; *C*—tests in W. race at 0.37 gate.

velocity should be in the neighborhood of 1½% below the meter velocity at the greater depths. It is not improbable that this would have been partly compensated for, had the observations in the east race been continued to Depths 5 and 6, but probably not entirely. In fact, there seems to be a reciprocal relation, as noted above, between the readings in the two races. This would follow naturally, owing to the symmetry of the flow in the races as to the central dividing wall, and the fact that the meters always rotate in the same direction. Thus, if there is an eddy clockwise at a certain position in either race, there should be a symmetrically located eddy counter-clockwise in the other race, and these might have opposite effects on the meter, the Pitot tube not being affected in the same way.

It is not impossible that the Haskell meter was running a trifle faster near the bottom of the race than the actual still-water ratings would indicate that it should. This would result from the fact that the rating boat was not a rigid support, nor was the water absolutely still during the ratings. This would necessitate shifting the rate line of the Haskell meter toward its ideal position of a maximum number of revolutions. This, in turn, would diminish all discharge records based on still-water ratings. On the other hand, to be consistent, it would follow that the rate line of the Gurley-Price meter would have to be shifted toward the maker's rate line, which would make for a larger correction to be added to velocities by the Haskell meter when based on still-water ratings, thus leaving true velocities in Table 5 practically unchanged. In corresponding manner, all the ratios of Tables 6 and 7 would be increased, while the meter velocities would be less in the same proportion, the effect of which would be to leave the corrected true velocities corresponding to the tables unaltered, they being in fact those of the Pitot tube. Thus, discharge estimates would not be affected materially in either case. The most reasonable explanation, however, is that the Pitot tube itself is variously affected by small amounts in different parts of the raceways.

The object, however, is not to speculate on such matters, but simply to check the computation of a small correction to the velocity, which correction may be in error by 50% and yet not affect the discharge measurements by the meter by more than three or four tenths of 1 per cent.

Interpolating a percentage for Depth 1, which was not observed in the tests, equal to the mean given for Depth 2, 1.055, and another in Depth 4, taking an average between the means for Depths 3 and 5, practically 1.000, there may be arranged the figures in Table 7.

TABLE 7.– AVERAGE CORRECTION FOR HASKELL METER, BASED ON COMPARISON OF CURRENT METER AND PITOT TUBE RECORDS.

Depths.	Ratio of velocity by Pitot tube to that by current meter, from Table 6.	Relative velocity in each horizontal, being a mean for Haskell meter.	Corrected relative meter velocity.
1.....	*1.055	10.20	10.76
2.....	1.055	11.86	12.51
3.....	1.001	13.50	13.51
4.....	*1.000	14.04	14.04
5.....	0.998	14.86	14.84
6.....	0.982	16.86	16.56
7.....	0.984	18.68	18.39
		100.00	100.61

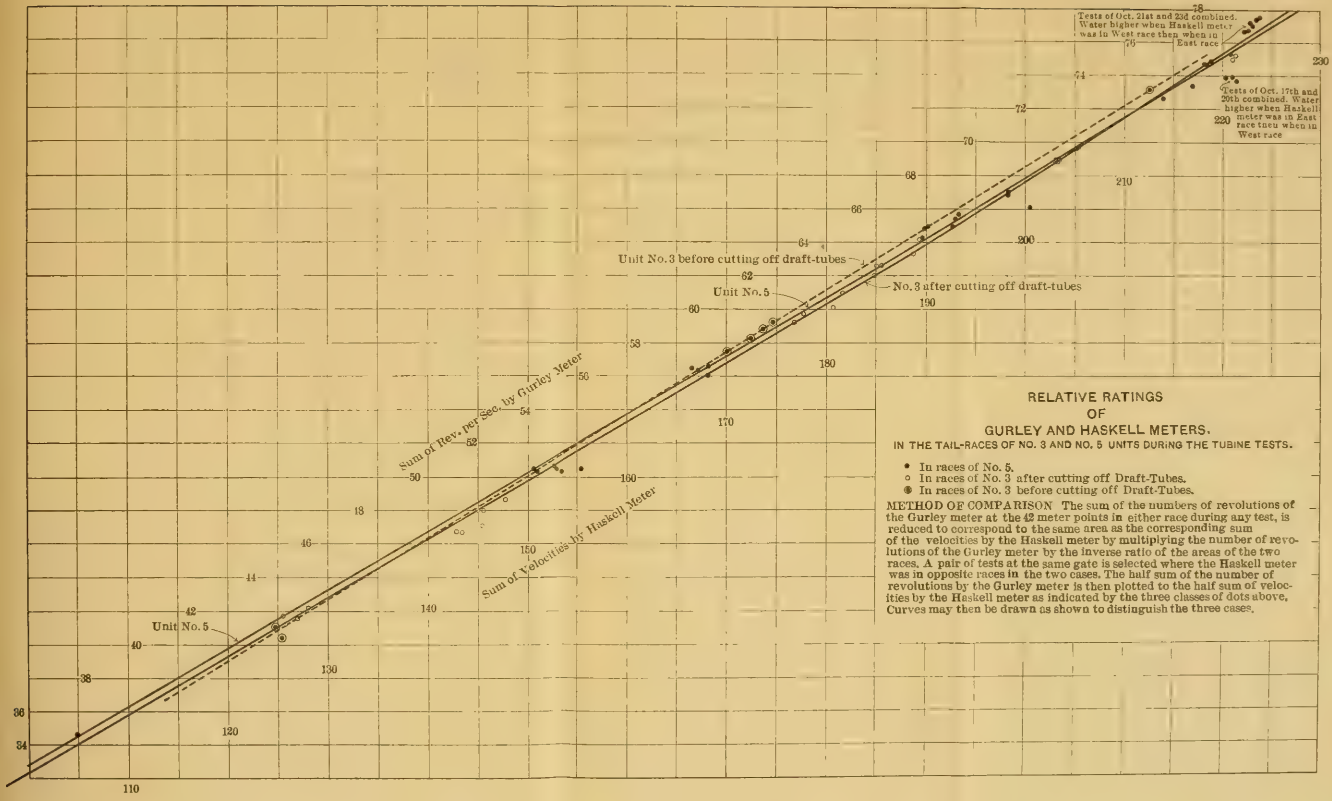
* Interpolated velocity ratio.

It follows from Table 7 that an approximate correction of 0.61% should be applied to discharges determined by the Haskell meter when used in these tail-races, and basing velocities on the still-water rating.

As a matter of fact, no direct use whatever was made of the still-water rating curves of the Gurley-Price meter, except to compute the corrections for the meters, which seem to be substantially verified by the Pitot tube tests. In reality, the Gurley-Price meter was rated relatively to the Haskell by comparisons of the simultaneous records taken by the meters in the two races during the numerous turbine tests.

While the Haskell meter runs in the west race, the Gurley-Price meter runs in the east race, and *vice versa.* If a pair of turbine tests be selected where the conditions are substantially the same, the Haskell meter being in the west race during one of the tests and in the east race during the other test, the total sum of the 84 velocities by the Haskell meter may be plotted to the total sum of the 84 numbers of revolutions per second by the Gurley-Price meter. If a number of such points be plotted, the curve drawn through them will represent the functional relation between the sum of the 84 velocities by the Haskell meter and the corresponding total sum of the numbers of revolutions per second by the Gurley-Price meter at the 84 meter points in the two races.

PLATE CXXXVII.
PAPERS, AM. SOC. C. E.
DECEMBER, 1912.
GROAT ON
CUP AND SCREW CURRENT METERS.



RELATIVE RATINGS
OF
GURLEY AND HASKELL METERS.
IN THE TAIL-RACES OF NO. 3 AND NO. 5 UNITS DURING THE TUBINE TESTS.

- ● In races of No. 5.
- ○ In races of No. 3 after cutting off Draft-Tubes.
- ◉ In races of No. 3 before cutting off Draft-Tubes.

METHOD OF COMPARISON The sum of the numbers of revolutions of the Gurley meter at the 42 meter points in either race during any test, is reduced to correspond to the same area as the corresponding sum of the velocities by the Haskell meter by multiplying the number of revolutions of the Gurley meter by the inverse ratio of the areas of the two races. A pair of tests at the same gate is selected where the Haskell meter was in opposite races in the two cases. The half sum of the number of revolutions by the Gurley meter is then plotted to the half sum of velocities by the Haskell meter as indicated by the three classes of dots above. Curves may then be drawn as shown to distinguish the three cases.

As the two races are so nearly alike, it may be accepted that, on the average, half the total sum of the 84 velocities will correspond to half the total number of revolutions per second at the 84 meter points, as a functional relation between the total sum of the velocities at the 42 meter points and the corresponding total sum of the revolutions per second at these points for either race taken separately.

Plate CXXXVII is such a relative rating curve, compiled from selected turbine tests, and may be used to reduce the records of the Gurley-Price meter to what they would have been by the Haskell meter. Thus, if in any tests on Unit No. 5 the Gurley-Price meter makes a total sum of revolutions per second of 50, then, by this curve, the Haskell meter would have made a record indicating a sum of 149.3 ft. per sec.

It was not found necessary to have any regard for the individual velocity by the meter at any point, except as a part of the total sum. A system of constants and ratios was devised, so that, to obtain the mean velocity in a raceway during any tests, it was merely necessary to multiply the sum of the velocities at the 42 meter points by a factor obtained from a curve. This, however, is a matter which the writer hopes to take up more in detail at another time, and therefore, he will confine himself here to the performance of the meters in the tail-races.

With this relative rating curve and the percentages of Tables 3 and 4, it would be quite possible to determine the absolute rating curve of either meter at each of the 84 meter points; but this is hardly necessary. It will suffice here, as a matter of interest, simply to conclude this paper by determining what the average absolute rating curve of the Gurley-Price meter was in the turbine tests. This may be done by dividing the numerical value of the abscissas and ordinates of Plate CXXXVII by 42 and plotting the resulting pairs of reduced co-ordinates to the corresponding reference lines in Plate CXXXVI.

It may there be seen that the number of revolutions per second by the Gurley-Price meter in the tail-races was, on the average, about 6% greater than the still-water rating would indicate. In other words, if the writer had relied on this meter alone, without any other guide than the still-water rating curve, his discharge results would undoubtedly have been 6% too high.

These conclusions are not to be taken as casting any reflections on the Gurley-Price meter, which according to the writer's experience, is an admirably constructed instrument. In fact, the results could not have been obtained without it. The rating of the meter was perfectly definite at each of the 84 meter points in the races, but could not be determined directly by means of the still-water rating, which, in reality, is the only thing at fault. The still-water rating should never be applied without regard to the probable deviations of the speed of revolution due to disturbances in the water. An excellent check on the meters is to rate them where operated with a Pitot tube.

ADDENDA.

Since the foregoing was written, the writer has had a very instructive experience with several types of meter used simultaneously on a complicated network of mountain streams. The results of oscillating the meters have confirmed the general conclusion that in all cases, relatively, cups are accelerated considerably, while screws are retarded slightly, in turbulent water. The errors of the cup meter, based on still-water ratings, were from 3 to 6 times greater than those of the screw, and in the contrary sense.

Design of Meters.—The principal desideratum of a current meter is that it gives the resolved component of velocity in a direction fixed relatively to the meter. The fact that a cup over-registers in turbulent water while a screw under-registers, gives a basis of design which may be used to produce a meter possessing this characteristic more or less rigidly. If the blades of a screw are "cupped" to the proper extent, and in the right sense, the effect may thus be toward neutralizing the retardation which the screw would otherwise suffer.

There are other ways of producing such a meter. Professors Greene and Moody, of Rensselaer Polytechnic Institute, have conducted a series of experiments there which resulted in the production of a meter practically giving only the resolved components of velocity.

A conclusion to be drawn from these experiences is that a tail, or rudder, is a useless appendage to a meter used in stream gauging. The meter should be held rigidly in the stream or conduit, giving only the component of velocity perpendicular to the cross-section. A cup meter would give better results in turbulent water if it had no tail, but was simply allowed to run at the end of a vertical rod like an inverted cup anemometer.

The recording device for a meter designed to be held rigidly in the current should register positively for down-stream current and negatively for up-stream current. There are cases where the current beneath the surface is up-stream and the old forms of meter make no distinction, as they should.

Accuracy of Velocity Determinations by Current Meters.—Under given conditions, the current meter is a very accurate instrument. To prove this, it is only necessary to take a series of observations at a given meter point, or better, at a given set of meter points, when conditions at the gauging section are constant. Repetitions of these observations will give results checking within 1 per cent.

It is not even necessary to take observations under constant conditions, as is shown by the writer's plottings of the sums of the metered velocities at selected sets of meter points at various gauging stations. These curves are drawn through the plottings of points the co-ordinates of which are the elevation of the water surface at the given gauging station and the sum of the velocities at a selected number (25 to 100) of meter points in the cross-section. In shallow streams the meter points should be at mid-depth.

Even in the case of shallow, turbulent, stony streams, such plotted points all lie within 1% of the finally determined curve, thus showing that the performance of the meter, be it of screw or cup type, is uniform and reliable.

The main sources of error are in the application of the still-water rating, the determination of the section area, and the determination of the distribution of flow through the cross-section. The errors due to an erroneous determination of the distribution of velocities are frequently styled the "errors due to the method of calculation."

Distribution Factor.—If the discharge and section area are determined accurately for any one gauging, the mean velocity in the section may be divided by the sum of the velocities at a selected set of meter points. This ratio may be called the distribution factor for the corresponding stage of the water. In this way, corresponding values of the distribution factor and stage of the river may be determined and plotted, the co-ordinates being the elevation of the water surface and corresponding value of the distribution factor. If the work has been good, the points will plot as close to a smooth curve as the plotting of points representing the sums of velocities at the selected set of meter points.

Section Area.—The section area, next to the error in applying the still-water rating, is probably the most uncertain element of a discharge determination, where the stream is shallow and stony. Nevertheless, it has been ascertained that the surface profile of such streams at reasonably good stations is a function of the stage of the water, in many cases being simply a horizontal line. By taking a minutely accurate profile of the bottom of such a stream along the cross-section, and a number of surface profiles at various stages, the section area may be plotted to the corresponding elevation of water surface. This is another element for the accurate determination of a discharge curve.

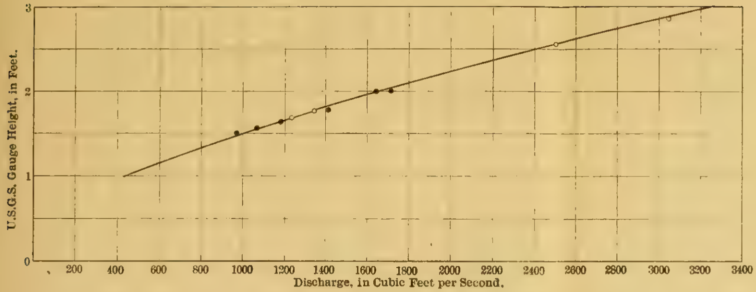
Statistical Synthesis of a Discharge Curve by Means of its Generating Elements.—According to the definitions given above, there are three principal generating elements of a discharge curve, all of which may be exhibited as curves plotted to the elevation of the water surface at the cross-section. These generating elements are, respectively, the sum of the velocities at a selected set of meter points, the distribution factor, and the area of cross-section.

If, for any given stage of water, the corresponding values taken from the curve of sums of velocities and the curve of distribution factors be multiplied together, the result is the mean velocity in the section for that stage. The product of this mean velocity and the section area taken from the area curve for the same stage is the discharge for that stage. In this way the discharges of the stream may be computed for all stages and plotted as a finally determined discharge curve.

The method is as strictly statistical as though the laws of probability had been applied formally, while the result is practically as satisfactory and infinitely easier to obtain. Moreover, errors are immediately detected and located.

Good work on the mountain streams of North Carolina and Tennessee has shown that individual discharge determinations based on the foregoing processes will plot within 1% or 2%, as extreme errors, of the final discharge curve.

Distribution of Flow.—The distribution of flow is determined in the ordinary manner by vertical velocity curves. It is best, however, to be systematic. A good system is to determine the ratio of the mid-depth velocity to the mean velocity in each vertical for the whole range

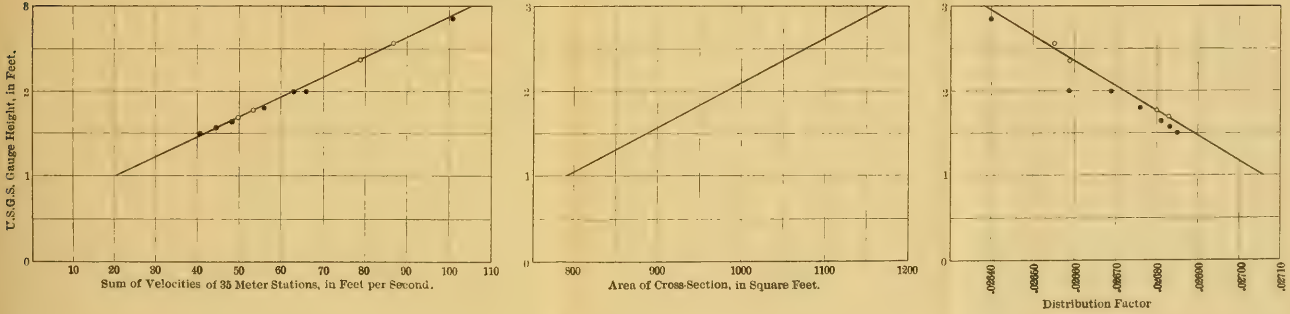


DISCHARGE CURVE FOR TUCKASEGEE RIVER AT BRYSON, N. C.

- ● Observations with Gurley Meter
- ○ Observations with Haskell Meter

The discharge curve has been computed from the elementary curves obtained from observations with the Haskell Meter.

The points spotted on the discharge curve indicate the individual discharge obtained from each gauging.



of stages of the river. The writer has used an average value of these ratios for each stage of the river, by which the mean mid-depth velocity for the corresponding stage is to be divided, in order to obtain the mean velocity in the section before computing a discharge. In practice, a curve may be drawn giving the mean value of the ratio for each stage of the river. The determination of this ratio is a different thing from a gauging for discharge.

Discharge Gauging.—As described above, the writer prefers to take gaugings of shallow rivers at mid-depth at equidistant stations along the cross-section. The individual discharge is then computed by dividing the sum of the products of the corrected mid-depth velocities and their corresponding areas by the average value of the before-mentioned ratio for the proper stage. The discharges at the ends of the section, below obstructions in the stream and around and through piers of bridges, should be treated separately under the title "end discharges" or "additional discharges." This additional discharge may be plotted as a function of the stage of the river. Such a plotting shows whether the calculation has been made on a consistent basis by forming a well-determined curve. Otherwise, the computer has varied his method of attack inconsistently.

Error in Using Average Ratios.—Undoubtedly, an error is made in using an average ratio of any sort, unless that average be determined properly. Thus a time average and a space average of a quantity are two entirely different things. It is important, therefore, to use the correct form of averages. However, if the values of the ratio of mid-depth velocity to mean velocity in thirty or forty verticals at a station of fairly uniform depth and velocity all lie between 1.10 and 1.18 as extremes, with an arithmetical average of about 1.14, no serious error can result in using such an average value. In fact, in this particular case, a detailed computation and one based on the average value of 1.14 differed by only one-seventh of 1 per cent.

Room for Research.—In the writer's opinion, it would pay scientific investigators to develop a meter which under all conditions would give the resolved component of velocity in a given direction, rather than to attempt to determine any functional relation between the deviations of cup and screw meters from their still-water ratings. In the foregoing studies of the results at Massena it was thought sufficiently accurate to consider the error of the cup meter about six times the error, in the contrary sense, of the screw meter. This ratio is undoubtedly a variable, but no serious error can result by assuming it to be constant where the extremes observed would make less than 1% difference in the discharge, as was the case in the turbine tests at Massena.

Practical Application of the Methods.—Table 8 exhibits the results of a number of discharge determinations at a station where the turbulence of flow is at a minimum. In fact, the disparity between the records of the Haskell and Gurley meters is less in these observations than for those at any of the other stations operated in North Carolina and Tennessee. The average ratio of mid-depth velocity to mean velocity for 45 vertical velocity curves is 1.055. The curve has not been drawn.

TABLE 8.—RESULTS OF A NUMBER OF DISCHARGE OBSERVATIONS TAKEN AT THE STATION AT THE WAGON BRIDGE, BRYSON, N. C.

Meter.	Gauge height.	*Sum of velocities in 35 verticals.	Section area.	Distribution factor.	Discharge.	Mean velocity.
Gurley	1.50	40.59	885.0	0.02685	965	1.090
Gurley	1.57	44.31	898.3	0.02684	1 068	1.189
Gurley	1.64	48.19	911.7	0.02681	1 179	1.292
Haskell	1.69	49.83	921.2	0.02683	1 230	1.337
Haskell	1.77	53.28	936.4	0.02680	1 338	1.429
Gurley	1.80	55.97	942.1	0.02676	1 410	1.498
Gurley	2.00	65.73	980.2	0.02659	1 713	1.748
Gurley	2.00	62.94	980.2	0.02669	1 646	1.680
Haskell	2.37	78.96	1 050.7	0.02659	2 208	2.100
Haskell	2.56	86.66	1 087.3	0.02655	2 502	2.301
Gurley	2.85	100.73	1 144.3	0.02640	3 044	2.660

*The velocities are here based solely on the still-water ratings of the meters.

Plate CXXXVIII shows the plottings of the main elements of the discharge observations of Table 8, according to the statistical methods described above. The discharge curve is determined by the three elementary curves, as already explained. The elementary curves are plotted from the records of the Haskell meter.

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INSTITUTED 1852

PAPERS AND DISCUSSIONS

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THE THEOREM OF THREE MOMENTS.*

By J. P. J. Williams, Assoc. M. Am. Soc. C. E.

The design of continuous beams, plate-girder draw spans, and swing-bridge trusses is based on the values of reactions and bending moments found by the use of a restricted form of the theorem of three moments, neglecting shear deflection. Theoretically, this usual restricted form applies only to beams built to conform accurately to the supports, which are assumed to be perfectly rigid and without possible settlement, and to beams with constant moments of inertia, and straight over the intermediate support. In practice, these conditions are never completely fulfilled. It is desirable, therefore, to determine the approximate value of the error introduced in such common practice. A complete general form of the theorem of three moments will be derived, and its application to a plate-girder draw span with variable moments of inertia will be made, in order to find the percentage of error introduced by the use of the usual formula. The theoretical maximum limit of the error thus introduced for such a typical case will be shown to be about 16.8% on the side of danger. Several fundamental and general relations for continuous beams will be given as the basis of the derivation, and also a direct derivation of the usual restricted form of the theorem. The subject matter will be divided into sections as follows:

Section 1.—The Continuous Beam.—Definition and Use of the Theorem of Three Moments.

Section 2.—Methods of Derivation.

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*This paper will not be presented at any meeting, but written communications on the subject are invited for publication with it in *Transactions*.

Section 3.—General Deflection Equations for Curved Beams and Arches.
Section 4.—Application to Fixed-Ended Arches.
Section 5.—Application to Simple Beams.
Section 6.—Fundamental General Relation for Continuous Beams.
Section 7.—General Values of Bending Moments, Shears, and Reactions, for any Span of a Continuous Beam.
Section 8.—Derivation of the Usual Restricted Form of the Theorem of Three Moments.
Section 9.—Effect of Settlement of Supports.
Section 10.—Derivation of the Complete General Form of the Theorem of Three Moments.
Section 11.—Application to Plate-Girder Draw Span with Variable Moment of Inertia.

SECTION 1.—THE CONTINUOUS BEAM.—DEFINITION AND USE OF THE THEOREM OF THREE MOMENTS.

The continuous beam resting on n supports, at which positive or negative reactions are developed, presents a problem in which the reactions are statically indeterminate. As n unknown reactions are to be found, and only two fundamental equations of static equilibrium are available, the solution of the problem requires $n - 2$ additional equations. The theorem of three moments, which was developed in its original form by Clapeyron in 1857, makes it possible to write the $n - 2$ equations required, and thus solve the problem. It is based on the relation between the elastic distortion in adjacent spans caused by the bending moments in those spans.

Definition of Theorem.—The theorem of three moments is expressed as an equation giving the algebraic relation which exists between the bending moments at any three consecutive supports of a continuous beam and the loading on the two included spans.

This algebraic relation is thus seen to be independent of the loading on the other spans outside of the two adjacent spans considered. It is directly affected by any movement or settlement of the supports, and the general form contains terms which give the effect of such settlement or of nonconformity to supports before loading. The application of the theorem equation to the $n - 2$ pairs of adjacent spans of a continuous beam with n supports, will give $n - 2$ simultaneous equations, in terms of the bending moments at the supports and the loading. The two end bending moments being known, there are only $n - 2$ unknown bending moments which, therefore, can be found at once either by algebraic solution or by the use of determinants. These bending moments at the supports being known, it is possible to find the reactions, also the shear and the bending moment for any span.

SECTION 2.—METHODS OF DERIVATION.

The theorem of three moments may be derived in either of two ways: First, the general bending-moment equation, $M = E\,I\,\frac{d^2 y}{dx^2}$, found by the common theory of flexure, can be used to find the slope, $\frac{dy}{dx}$, at the intermediate support, and the values as found from the equations for the two adjacent spans equated when the beam is straight over the intermediate support. Second, a more general fundamental relation between the end deflections for the two adjacent spans, when the beam is not straight, can be derived from the fact that the angle between the tangents at the intermediate support will remain constant, and this relation may be used in the derivation.

The first method is usually given in textbooks, and results only in the restricted form of the theorem. The second method is used by F. E. Turneaure,* Assoc. M. Am. Soc. C. E., for a straight beam with constant moment of inertia, also by W. H. Burr,† M. Am. Soc. C. E., for the perfectly general case of any curved beam. This second method will be applied here, both for the derivation of the restricted form and for the general form of the theorem. It is based directly on a general formula giving the relative vertical deflection, D_v, of any point due to bending, in terms of the bending moments along the beam. This general deflection formula will now be derived.

SECTION 3.—GENERAL DEFLECTION EQUATIONS FOR CURVED BEAMS AND ARCHES.

Let Fig. 1 represent a perfectly general case of a fixed-ended arch subjected to elastic bending stress throughout its length. By assuming a very short length, $N_1\,N = n$, the value of the bending moment, M, can be considered as practically constant throughout such length and equal to its value at, say, N; also, the summations and co-ordinates can be taken from N_1 or N, indiscriminately. The differential amount of the deflection of any other point, O, can then be found by considering the movement of the chord, NO, due to the elastic bending in the short length, $N_1 N = n$. For the total deflection caused by elastic bending in the whole length, $N_1 O$ or NO, the summation of these differential deflections can be made. In this manner the general equations for change in angle, and for horizontal and vertical components of total deflection due to elastic bending, can now be derived.

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* "Modern Framed Structures," Vol. II.

† "Elasticity and Resistance of Materials."

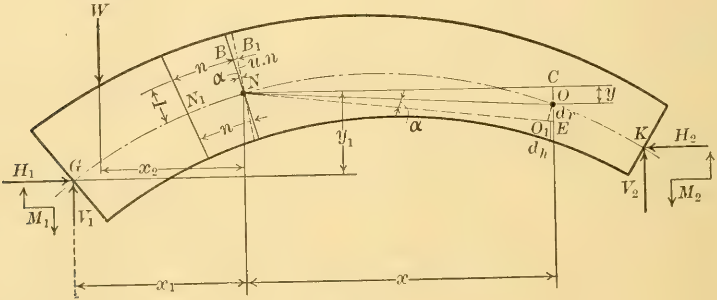

FIG. 1.

Notation.—The notation is indicated by Fig. 1, and also:

n = any small length, $N_1 N$, along a neutral axis (theoretically, a differential length; practically, often some convenient length).

M = the general value of the bending moment at any given point, N, considered as an average value for the distance, n, namely, $M = M_1 + V_1 x_1 - H_1 y_1 - \Sigma W x_2$.

α = a small angle in radians between the plane normal section, $N B$, before bending, and its position, $N B_1$, after bending has occurred in the distance, n. The slight effect of 'variation in distance, $N_1 N$, when the normal planes at N_1 and at N are not parallel, is negligible.

$A = \sum_{O}^{N} \alpha =$ the total angular change = the change in angle between the end tangents at N and O.

d_h and D_h = the differential and total horizontal components of deflection of O, referred to a fixed tangent at N.

d_v and D_v = the corresponding vertical components of deflection of O.

u = the rate of strain at a unit distance from the neutral axis.

f_1 = the intensity of stress at a unit distance from the neutral axis.

E = the coefficient of elasticity.

I = the moment of inertia of the normal section, $N\ B$ = the average for all normal sections in length, n.

Drawing the chord, NO, N is taken as the instantaneous center for the revolution of the point, O, due to bending, in the length, n, only, and since no bending occurs yet in the length, NO, the chord remains at a constant angle with the normal plane, NB, and revolves with that plane through the angle, α. OO_1 then represents the deflection of O due to bending in the length, n, and d_h and d_v, the two components of such deflection, are $O_1\ E$ and $O\ E$, respectively.

Now, by the definition of the rate of strain, u:

$$B\ B_1 = un;$$

and, by the common theory of flexure,

$$M = f_1\ I = u\ EI. \quad \text{Therefore, } u = \frac{M}{EI} \dots\dots\dots\dots (1)$$

From the triangle, NBB_1, as α is small:

$$\alpha = \tan.\ \alpha = u\ n \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Therefore, from Equation (1):

$$\alpha = \frac{Mn}{EI} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Then the total summation of these angular changes in length, ON, would be:

$$A = \sum_O^N \alpha = \sum_O^N \frac{Mn}{EI} \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Considering the similar triangles, $OO_1\ E$ and OCN:

$$\frac{O_1E}{OO_1} = \frac{OC}{ON}; \text{ therefore, } d_h = O_1E = \frac{OO_1\ OC}{ON} = \frac{OO_1}{ON}\,y.$$

Also, $\dfrac{OE}{OO_1} = \dfrac{NC}{ON}$; therefore, $d_v = OE = \dfrac{OO_1\ NC}{ON} = \dfrac{OO_1}{ON}\,x.$

But $\dfrac{OO_1}{ON} = \tan.\ \alpha = \alpha = \dfrac{Mn}{EI}$, from Equation (3), which, when substituted in the above values for d_h and d_v, will give:

$$d_h = \frac{Mn}{EI}\,y \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

$$\text{and } d_v = \frac{Mn}{EI}\,x \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

The total deflections, D_h and D_v, of the point, O, due to bending in the length, ON, therefore, will be the summation of these elementary deflections, giving:

$$D_h = \sum_{0}^{N} \frac{Mn}{EI} y \qquad (7)$$

$$D_v = \sum_{0}^{N} \frac{Mn}{EI} x \qquad (8)$$

It should be clearly understood that the values obtained by making the summations indicated in Equations (4), (7), and (8) will give the resulting effects of bending in the length, ON or ON_1, only. If bending occurs outside the portion, ON or ON_1, considered, it causes a deflection of both O and N or N_1, and affects their relative deflection with respect to each other. Therefore, Equations (7) and (8) give the relative horizontal and vertical deflections of O, with respect to N or N_1, only when the bending does not change the position of the original normal plane of reference at N or N_1. As a tangent to the neutral axis at N or N_1 is perpendicular to such normal plane, it follows that both tangent and normal plane at the end, N or N_1, of the section considered must remain fixed, if such equations are to give relative total deflections.

The origin for the co-ordinates, x and y, is at O, the point for which the deflection is being found. It is evident that this is really a moving point, as it is being deflected, but the relative amount of such deflection is insignificant in comparison with the values of x and y.

SECTION 4.—APPLICATION TO FIXED-ENDED ARCHES.

Perhaps the most important application of General Equations (4), (7), and (8), is to the case of the fixed-ended concrete or reinforced concrete arch, which is statically indeterminate to the third degree, there being six unknowns and only three fundamental equations of equilibrium, $\Sigma H = 0$, $\Sigma V = 0$, and $\Sigma M = 0$. Such an arch is assumed to have fixed end tangents and to sustain no relative deflections, either horizontal or vertical, between the ends, that is, the abutments are assumed to be absolutely rigid at G and K, Fig. 1. Such assumptions would make the values of Equations (4), (7), and (8), each equal to zero, when the summations are made for the total length, *G* to *K*, giving the following three fundamental equations for elastic equilibrium, which make the problem determinate:

$$\text{From Equation (4)},\quad \sum_G^K \frac{Mn}{EI} = 0 \text{ . . . . (9)}$$

$$\text{From Equation (7)},\quad \sum_G^K \frac{Mn}{EI}\, y = 0 \text{ . . . . (10)}$$

$$\text{From Equation (8)},\quad \sum_G^K \frac{Mn}{EI}\, x = 0 \text{ . . . . (11)}$$

It should be noted that these equations are based on deflections due to bending only, and do not account for the effect of direct thrust, shear, or temperature changes.

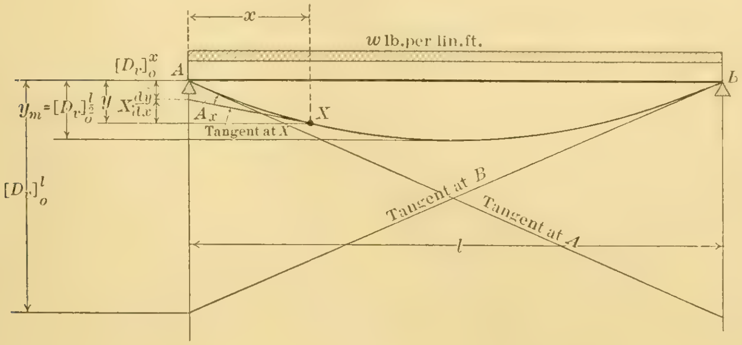

FIG. 2.

SECTION 5.—APPLICATION TO SIMPLE BEAMS.

In order to illustrate the use of Equation (8), giving the relative vertical deflection, D_v, before applying it to the case of the continuous beam, consider the simple beam uniformly loaded, as in Fig. 2. E and I will be assumed as constant and $n = dx$. Then Equation (8) becomes $D_v = \frac{1}{EI}\int_0^x Mx\,dx$, in general for the length, AX. The general value of M, for uniform load, w, per foot, is:

$$M = \frac{w}{2}\, x\,(l - x).$$

$$\text{Therefore, } [D_v]^x{}_0 = \frac{w}{2\,EI}\int_0^x (l - x)\, x^2\, dx = \frac{w}{2\,EI}\left[\frac{lx^3}{3} - \frac{x^4}{4}\right] \text{. . . (12)}$$

If the integration is made for the half length, the maximum deflection, y_m, is obtained:

$$[D_v]_0^{\frac{l}{2}} = y_m = \frac{w}{2\ EI}\left[\frac{l^4}{24} - \frac{l^4}{64}\right]$$

or,

$$y_m = \frac{5\ wl^4}{384\ EI} \quad \text{.......................} \quad (13)$$

If the integration is made for the whole length:

$$[D_v]_0^l = \frac{w}{2\ EI}\left[\frac{l^4}{3} - \frac{l^4}{4}\right] = \frac{wl^4}{24\ EI} \quad \text{............} \quad (14)$$

It is thus evident that the expression for D_v, when integrated for the total length, l, of a simple span, will not give zero (the relative deflection of the ends), but the value of the vertical movement of the end tangent at the other end, B, below the end, A. That this General Equation (8) cannot be applied to cases where vertical deflection with respect to supported ends which are not fixed is desired can be seen by considering the form of the equation. Such an equation would result by making a double integration of the fundamental deflection equation of the common theory of flexure, $\frac{d^2 y}{dx^2} = \frac{M}{EI}$, omitting entirely the first constant of integration, giving $y = \int \frac{Mx\ dx}{EI} = D_v$, and also introducing x as a multiplier of M instead of some constant multiplied by x, which would result if the proper integration were made and M contained terms in x.

The second constant of integration which would now be introduced in either case is always zero, as $y = 0$ when $x = 0$. The first constant of integration is really the value of the slope, $\frac{dy}{dx}$, of the end tangent at the origin, A.

From Equation (14) it is seen that the end tangent at B has a slope, $\frac{wl^4}{24\ EI} \div l = \frac{wl^3}{24\ EI}$. This value can be checked by the ordinary equations of deflection for such a beam, found by integrating the fundamental equation, $\frac{d^2 y}{dx^2} = \frac{M}{EI}$, and will be the first constant of integration. It can also be checked by using Equation (4) for change in angle, A, because, for small angles, tan. $A = A$. In general, when $n = dx$ and $E\ I$ is constant, Equation (4) gives:

$$A_x = \int_0^x \frac{M dx}{EI} = \frac{w}{2\ EI} \int_0^x (l - x)\, x dx = \frac{w}{2\ EI}\left[\frac{lx^2}{2} - \frac{x^3}{3}\right] \ldots\ldots (15)$$

The slope of the end tangent at B with respect to the horizontal tangent at the center is then found by integrating from 0 to $\frac{l}{2}$, that is, let $x = \frac{l}{2}$ in Equation (15).

$$A = \frac{dy}{dx} = \frac{w}{2\ EI}\left[\frac{l^3}{8} - \frac{l^3}{24}\right] = \frac{wl^3}{24\ EI} \ldots\ldots\ldots\ldots (16)$$

The total deflection, y, at any point, x, is not given by the D_v Equation (12), but can be found by adding to $\left[D_v\right]_0^x$ the quantity obtained by multiplying the slope at X by x, as is seen in Fig. 2. The value of the slope, $\frac{dy}{dx}$, at X can be found either by the integration of the fundamental equation, $\frac{d^2 y}{dx^2} = \frac{M}{EI}$, or by using Equation (12) for A_x. The latter can be shown to check the former method as follows, as A_x is the angle between the tangents at A and at X:

$$\frac{dy}{dx} \text{ at } X = \text{slope at } A - A_x = \frac{wl^3}{24\ EI} - \frac{w}{2\ EI}\left(\frac{lx^2}{2} - \frac{x^3}{3}\right)$$

$$= -\frac{w}{2\ EI}\left[\frac{lx^2}{2} - \frac{x^3}{3} - \frac{l^3}{12}\right] \ldots\ldots\ldots\ldots\ldots (17)$$

Equation (17) checks the value obtained by general integration, but with opposite sign.

The total deflection, y (using Equations (12) and (17)), therefore, is:

$$y = \left[D_v\right]_0^x + x\left(\frac{dy}{dx} \text{ at } X\right) = \frac{w}{2\ EI}\left[\frac{lx^3}{3} - \frac{x^4}{4} - \frac{lx^3}{2} + \frac{x^4}{3} + \frac{l^3 x}{12}\right]$$

$$\text{Therefore, } y = -\frac{w}{24\ EI}\left[2\ lx^3 - x^4 - l^3 x\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

Equation (18) checks the value obtained by general integration, but with opposite sign.

It should be explained that the difference in sign is due to the fact that the D_v Equation gives positive values for deflection when the positive bending moment occurs, while, in the notation for deflection by the general integration of $\frac{d^2 y}{dx^2} = \frac{M}{EI}$, the deflection is downward or negative for the positive bending moment.

It is also important to observe that the origin for x in the D_v Equation is at the deflecting point, the result being positive if that point has deflected upward with respect to the tangent at the other end of the section considered. No constants of integration are introduced in the foregoing, as they are zero.

Whenever concentrated loads occur, it is necessary to make separate integrations for each segment of the beam, because the law of variation of the bending moment with x will change at each load.

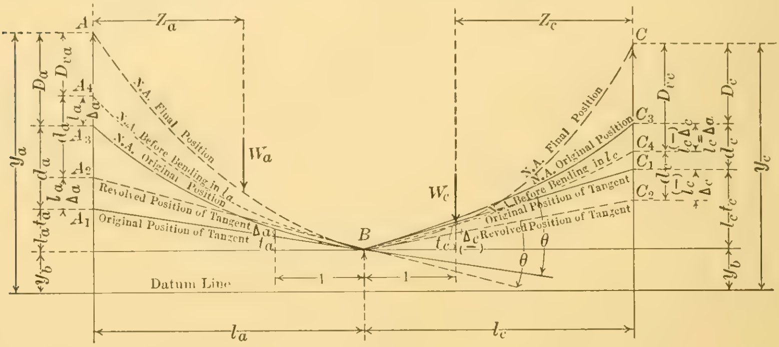

FIG. 3.

The deflection, $y_m - y$, at any point, X, cannot be obtained from the integrated value for D_v in Equation (12), because the origin for x is not at X. The bending moment, M, must first be written in terms of x_1 (say) with X as the origin, and the integration made by the General Equation, $D_v \mp \int \frac{Mx\,dx}{EI}$. If, however, the bending moment, M, is constant in the section considered, as, for instance, in the case of a simple beam loaded with two symmetrical concentrated loads, the deflection between the center and the load on either side can be obtained by Equation (12), because M has the same value, regardless of the origin used.

SECTION 6.—FUNDAMENTAL GENERAL RELATION FOR CONTINUOUS BEAMS.

Consider two adjacent spans, l_a and l_c, of any continuous beam with a curved neutral axis (N. A. Fig. 3) resting only on the intermediate support, *B*, before the application of loads. Neglecting the effect of deflection due to shear, a fundamental equation based on the fact that the tangents to the neutral axes at *B*, for the two adjacent spans, remain at a constant fixed angle with each other, may be derived as follows:

Let t_a = the tangent of the angle between the original position of the tangent at *B* for the span, l_a, and the horizontal.

Δ_a = the change in t_a due to the rotation of the tangent at *B*.

D_a = the vertical distance from the original position of the neutral axis to the support, *A*, + if upward.

d_a = the vertical distance at *A* between the original tangent and the original neutral axis.

D_{va} = the total vertical deflection of the neutral axis at *A* due to bending in the span, l_a, only, that is, $D_{va} = \sum_A^B \frac{Mnx}{EI}$.

t_c, Δ_c, D_c, d_c, D_{vc} = the corresponding quantities for the span, l_c, as shown.

y_a, y_b, and y_c = the elevations of the supports, *A*, *B*, and *C*.

The vertical movement, D_a, at *A*, between the original and final positions of the neutral axis, is seen to be composed of two parts: First, the movement, $A_3\ A_4$, due to the rotation of the tangent at *B*; and second, the movement or deflection, $A_4\ A$, due to the bending in the span, l_a, with respect to the tangent at *B*. This rotation of the tangent at *B* would certainly occur in the general case. The bending deflection for the span, l_a, only, is not equal to the total movement, D_a, except for the special case of symmetry about *B* such that no movement of the tangents at that point would take place.

From a consideration of Fig. 3, it is seen that the vertical movement at *A* between the original and final positions of the tangent is $A_1\ A_2 = l_a\ \Delta_a$; and the corresponding movement of the neutral axis vertically at *A* is $A_3\ A_4$, and also $= l_a\ \Delta_a$, because d_a remains practically constant. The bending deflection, $D_{va} = A_4\ A$, in the span, l_a, is the other portion of the movement, $A_3\ A$, of the neutral axis to bring it to the support at *A*. This deflection, by Equation (8), is:

$$D_{va} = \sum_A^B \frac{Mnx}{EI}.$$

If the + M terms are greater than the − M terms, D_{va} is + or upward, as shown. Note that the origin is at A.

As θ is constant:

$$\Delta_a = -\Delta_c \quad \text{(19)}$$

and, from Fig. 3,

$$D_{va} = D_a - l_a\,\Delta_a \quad \text{(20)}$$

Also.

$$D_{vc} = D_c - l_c\,\Delta_c = D_c + l_c\,\Delta_a \quad \text{(21)}$$

Solve Equations (20) and (21) for Δ_a, and equate:

$$\Delta_a = \frac{D_a - D_{va}}{l_a} = \frac{D_{vc} - D_c}{l_c}$$

whence,

$$\frac{D_a}{l_a} + \frac{D_c}{l_c} = \frac{D_{va}}{l_a} + \frac{D_{vc}}{l_c} \quad \text{(22)}$$

Substituting the values of D_{va} and D_{vc}:

$$\frac{D_a}{l_a} + \frac{D_c}{l_c} = \frac{\sum_A^B \frac{Mnx}{EI}}{l_a} + \frac{\sum_C^B \frac{Mnx}{EI}}{l_c} \quad \text{(23)}$$

Equation (23) is the fundamental and perfectly general equation by which the theorem of three moments can be developed by determining values for the summations indicated in the second member. As a check on Equations (22) and (23), consider the usual case of a horizontal beam resting on three supports, A B C. Assume a single load, W, on one span only; the final position of the neutral axis and the tangent at B would be as shown in Fig. 4. For this case, $D_a = 0$, $D_c = 0$, and Equation (22) gives:

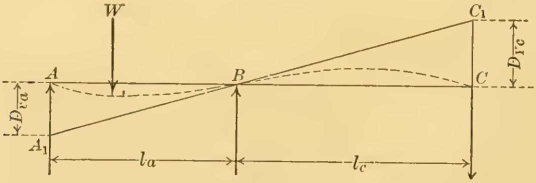

FIG. 4.

$$0 = \frac{D_{va}}{l_a} + \frac{D_{vc}}{l_c};\ \text{whence,}\ \frac{D_{va}}{l_a} = -\frac{D_{vc}}{l_c}.$$

This agrees with the result of considering the similar triangles, $AA_1\,B$ and BCC_1, as D_{vc} would be negative.

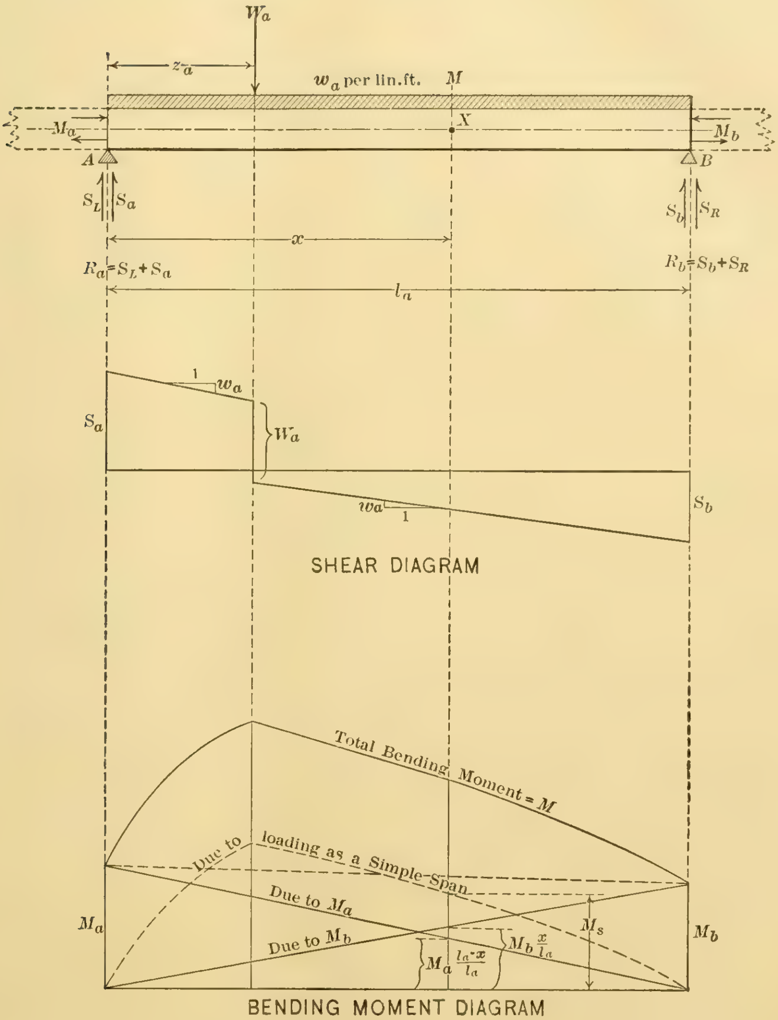
W_a
z_a
w_a per lin.ft.
M
X
M_a
M_b
A
B
S_L
S_a
S_b
S_R
x
$R_a = S_L + S_a$
$R_b = S_b + S_R$
l_a
1
w_a
S_a
W_a
w_a
1
S_b
SHEAR DIAGRAM
Total Bending Moment = M
Due to loading as a Simple-Span
Due to M_a
Due to M_b
M_a
M_s
$M_b \frac{x}{l_a}$
$M_a \frac{l_a - x}{l_a}$
M_b
BENDING MOMENT DIAGRAM

FIG. 5.

Section 7.—General Values of Bending Moments, Shears, and Reactions, for Any Span of a Continuous Beam.

Consider any span, *AB*, of a continuous beam, Fig. 5, and let:

M_a = the bending moment at *A* (from the theorem of three moments).

M_b = the bending moment at *B* (from the theorem of three moments).

M_s = the bending moment at *X*, due to the loading on l_a as a simple span.

M = the total bending moment at *X*.

S_L = the reaction at *A* from the span to the left of *A* = — shear to the left of *A*.

S_a = the reaction at *A* from the span, l_a = shear to the right of *A*.

S_R = the reaction at *B* from the span to the right of *B* = shear to the right of *B*.

S_b = the reaction at *B* from the span, l_a = — shear to the left of *B*.

R_{sa} = the reaction at *A* from the span, l_a, as a simple beam.

R_{sb} = the reaction at *B* from the span, l_a, as a simple beam.

$R_a = S_L + S_a$ = the total reaction at *A*.

$R_b = S_b + S_R$ = the total reaction at *B*.

To find the value of S_a, for the given span, write the equation for the value of the bending moment at $B = M_b$, considering all forces acting on the span, l_a:

$$M_b = M_a + S_a\,l_a - w_a\,\frac{l_a^2}{2} - W_a\,(l_a - z_a) \dots\dots\dots\dots (24)$$

Solving for S_a:

$$S_a = \frac{M_b - M_a}{l_a} + \frac{w_a\,l_a}{2} + W_a\,\frac{l_a - z_a}{l_a} = \frac{M_b - M_a}{l_a} + R_{sa} \dots (25)$$

Note that if $M_a = M_b$, $S_a = R_{sa}$.

Similarly:

$$S_b = \frac{M_a - M_b}{l_a} + R_{sb} \dots\dots\dots\dots\dots\dots\dots\dots (26)$$

Or, S_b = (the total loading on l_a) — S_a. . . . . (26*a*)

The values of M_a and M_b are first found from the theorem of three moments, and are generally negative. The sign must always be included in making substitutions in the foregoing formulas.

Having found the values of S_a and S_b for adjacent spans, the reactions are at once found by addition, noting that $S_L =$ the S_b for the span on the left, and $S_R =$ the S_a for that on the right.

The general value for M, at any point, X, can be stated in two ways:

First, $M = M_a + S_a\,x -$ (moment of loads on l_a to left of X about X) ....(27)

Second, $M = \dfrac{M_a\,(l_a - x)}{l_a} + \dfrac{M_b\,x}{l_a} + M_s$ ....(28)

This second form is seen to result at once from similar triangles, in Fig. 4, and shows that M can be considered as composed of three distinct parts: (a) that due to M_a; (b) that due to M_b; and (c) that due to loads on l_a as a simple beam. The terms due to (a) and (b) can also be explained by noting that these end bending moments produce vertical couples; $+ M_a$ produces a force, $+\dfrac{M_a}{l_a}$, at B, and $-\dfrac{M_a}{l_a}$, at A, and similarly, M_b gives a force couple, $+\dfrac{M_b}{l_a}$, at A, and $-\dfrac{M_b}{l_a}$, at B. These forces, produced as vertical couples to balance M_a and M_b, also explain the form of Equations (25) and (26) for S_a and S_b.

SECTION 8.—DERIVATION OF THE USUAL RESTRICTED FORM OF THE THEOREM OF THREE MOMENTS.

For the usual practical case, the beam is straight, rests on the supports, may slope at an angle, B, with the horizontal, and E and I are assumed as constant throughout the entire length. For such a case, then:

$D_a = 0$, $D_c = 0$, $n = dx$ sec. B, and Equation (23) becomes:

$$0 = \frac{\displaystyle\int_0^{l_a} \frac{M\,x\,dx \text{ sec. } B}{EI}}{l_a} + \frac{\displaystyle\int_0^{l_c} \frac{M\,x\,dx \text{ sec. } B}{EI}}{l_c}$$

As sec. B, E, and I, are constant, they can be multiplied out, and

$$\int_0^{l_a} \frac{M\,x\,dx}{l_a} + \int_0^{l_c} \frac{M\,x\,dx}{l_c} = 0 \text{ ....(29)}$$

To integrate $\int_0^{l_a} M\,x\,dx$, substitute for M the general value from Equation (28),

$$\int_0^{l_a} M\,x\,dx = \frac{M_a}{l_a}\int_0^{l_a}(l_a - x)\,x\,dx + \frac{M_b}{l_a}\int_0^{l_a} x^2\,dx + \int_0^{l_a} M_s\,x\,dx. \quad (30)$$

The first term becomes, $\frac{M_a}{l_a}\left[\frac{l_a\,x^2}{2} - \frac{x^3}{3}\right] = \frac{M_a\,l_a^2}{6}$;

the second term becomes, $\frac{M_b}{l_a} \times \frac{l_a^3}{3} = \frac{2\,M_b\,l_a^2}{6}$.

The third term in M_s consists of three parts: First, the bending moment in the segment, z_a, due to the concentrated load, W_a, that is, $\frac{W_a\,(l_a - z_a)}{l_a}\,x$; second, the bending moment in the segment, $l_a - z_a$, due to the concentrated load, W_a, that is, $\frac{W_a\,z_a}{l_a}\,(l_a - x)$; and third, the bending moment at any point due to the uniform load, w_a, that is, $\frac{w_a\,x}{2}\,(l_a - x)$.

Using these values, the third term then becomes:

$$\int_0^{l_a} M_s x\,dx = \frac{W_a}{l_a}\left[\int_0^{z_a}(l_a - z_a)\,x^2\,dx + z_a\int_{z_a}^{l_a}(l_a - x)\,x\,dx\right] + \frac{w_a}{2}\int_0^{l_a}(l_a - x)\,x^2\,dx = \frac{W_a}{l_a}\left[(l_a - z_a)\,\frac{z_a^3}{3}\right.$$

$$\left. + z_a\left(l_a\,\frac{x^2}{2} - \frac{x^3}{3}\right)_{z_a}^{l_a}\right] + \frac{w_a}{2}\left[l_a\,\frac{x^3}{3} - \frac{x^4}{4}\right]_0^{l_a} = \frac{W_a}{l_a}\left[\frac{l_a\,z_a^3}{3}\right.$$

$$\left. - \frac{z_a^4}{3} + \frac{z_a\,l_a^3}{2} - \frac{z_a\,l_a^3}{3} - \frac{l_a\,z_a^3}{2} + \frac{z_a^4}{3}\right] + \frac{w_a\,l_a^4}{24}$$

$$\int_0^{l_a} M_s\,x\,dx = \frac{W_a\,z_a}{6}\,(l_a^2 - z_a^2) + \frac{w_a\,l_a^4}{24} \quad \ldots\ldots\ldots(31)$$

Substituting the foregoing values in Equation (30):

$$\int_0^{l_a} M\,x\,dx = \frac{M_a\,l_a^2 + 2\,M_b\,l_b^2 + W_a\,z_a\,(l_a^2 - z_a^2) + \frac{w_a\,l_a^4}{4}}{6} \quad \ldots(32)$$

By analogy, for the span, l_c;

$$\int_0^{l_c} M\,x\,dx = \frac{M_c\,l_c^2 + 2\,M_b\,l_c^2 + W_c\,z_c\,(l_c^2 - z_c^2) + \frac{w_c\,l_c^4}{4}}{6} \quad \ldots(34)$$

Substituting these values in Equation (29), eliminating the factor, 6, and transposing:

$$M_a\,l_a + 2\,M_b\,(l_a + l_c) + M_c\,l_c = -\,\Sigma\,W_a\,\frac{z_a}{l_a}\,(l_a^2 - z_a^2)$$

$$-\,\Sigma\,W_c\,\frac{z_c}{l_c}\,(l_c^2 - z_c^2) - \frac{w_a\,l_a^3}{4} - \frac{w_c\,l_c^3}{4} \quad \ldots.(35)$$

The terms in W_a and W_c have the summation sign introduced in order to account for all such concentrated loads on the spans. Equation (35) is the usual restricted form of the theorem of three moments, and is used in general for all cases of continuous beams, even for swing-bridge trusses, where the neutral axis is not straight and the moment of inertia is not constant.

SECTION 9.—EFFECT OF SETTLEMENT OF SUPPORTS.

The foregoing form of the theorem assumes that the beam just rests on rigid supports. If the supports should settle, the values, D_a and D_c, would no longer be zero, but would be equal to the amount of such relative settlement. Assuming the beam to be straight, but having a slope, B, with the horizontal, Equation (23) becomes (as EI and sec. B are constant, n being equal to dx sec. B):

$$\frac{EI}{\sec. B}\left[\frac{D_a}{l_a} + \frac{D_c}{l_c}\right] = \int_0^{l_a} \frac{M\,x\,dx}{l_a} + \int_0^{l_c} \frac{M\,x\,dx}{l_c} \quad \ldots .(36)$$

The second member of this equation is the same as that in Equation (29), which has been integrated in Equation (35). Thus, the only difference between Equation (35) and this case, is that the term, $\frac{6\,EI}{\sec.\ B}\left[\frac{D_a}{l_a} + \frac{D_c}{l_c}\right]$, must be added, the factor, 6, having been multiplied out in getting Equation (35). The equation would then be:

$$M_a\,l_a + 2\,M_b\,(l_a + l_c) + M_c\,l_c = -\,W_a\,\frac{z_a}{l_a}\,(l_a^2 - z_a^2)$$

$$-\,W_c\,\frac{z_c}{l_c}\,(l_c^2 - z_c^2) - \frac{w_a\,l_a^3}{4} - \frac{w_c\,l_c^3}{4} + \frac{6\,EI}{\sec. B}\left[\frac{D_a}{l_a} + \frac{D_c}{l_c}\right] \quad ..(37)$$

This last term would be large, as it contains the multiplier, $E\ I$, and would be additive in effect if D_a and D_c were negative, that is, when the end supports settled downward with respect to the intermediate support.

All computations for bending moments, M, are made in foot-pounds or foot-kips, therefore, the last term should be put in form for such computation by dividing by 12^2, as E and I are in inches, and D_a and D_c are in feet. Therefore, the last term of Equation (37) becomes:

$$\frac{EI}{24\ \sec.\ B}\left[\frac{D_a}{l_a} + \frac{D_c}{l_c}\right] \ldots\ldots\ldots\ldots\ldots\ldots (37a)$$

For the usual case of a horizontal beam, sec. $B = 1$.

SECTION 10.—DERIVATION OF THE COMPLETE GENERAL FORM OF THE THEOREM OF THREE MOMENTS.

The most general form of the theorem of three moments, applicable to any curved continuous beam with a variable moment of inertia and not originally resting on all supports, can be derived directly from the fundamental Equation (23). It is only necessary to obtain a general working form for the summations appearing in the second member of that equation, as follows:

Using the general value for M, as derived for Equation (18), there results:

$$\sum_A^B \frac{Mn\,x}{EI} = \sum_A^B \left[\frac{M_a}{l_a}(l_a - x) + \frac{M_b\,x}{l_a} + M_s\right]\frac{n\,x}{EI} \;..(38)$$

Let $n = dx$ sec. β, and assume E to be constant, then:

$$\sum_A^B \frac{Mn\,x}{EI} = \frac{1}{l_a\,E}\Bigg[M_a \sum_A^B (l_a - x)\,x\,dx\,\frac{\text{sec. }\beta}{I} + M_b \sum_A^B x^2\,dx\,\frac{\text{sec. }\beta}{I} + l_a \sum_A^B M_s\,x\,dx\,\frac{\text{sec. }\beta}{I}\Bigg] \ldots\ldots (39)$$

By analogy, for span, l_c:

$$\sum_C^B \frac{Mn\,x}{EI} = \frac{1}{l_c\,E}\Bigg[M_c \sum_C^B (l_c - x)\,x\,dx\,\frac{\text{sec. }\beta}{I} + M_b \sum_C^B x^2\,dx\,\frac{\text{sec. }\beta}{I} + l_c \sum_C^B M_s\,x\,dx\,\frac{\text{sec. }\beta}{I}\Bigg] \ldots\ldots. (40)$$

By substituting the foregoing values in Equation (23), the following General Equation results:

$$E\left(\frac{D_a}{l_a} + \frac{D_c}{l_c}\right) = \frac{M_a}{l^2_a} \sum_A^B (l_a - x)\,x\,dx\,\frac{\text{sec. }\beta}{I} + M_b\left(\frac{\sum_A^B x^2\,dx\,\frac{\text{sec. }\beta}{I}}{l^2_a} + \frac{\sum_C^B x^2\,dx\,\frac{\text{sec. }\beta}{I}}{l^2_c}\right) + \frac{M_c}{l^2_c}\sum_C^B (l_c - x)\left(x\,dx\,\frac{\text{sec. }\beta}{I}\right) + \frac{\sum_A^B M_s\,x\,dx\,\frac{\text{sec. }\beta}{I}}{l_a} + \frac{\sum_C^B M_s\,x\,dx\,\frac{\text{sec. }\beta}{I}}{l_c} \;..(41)$$

This equation is the most general form of the theorem of three moments. Whenever the variables, sec. β and I, can be expressed as continuous functions of x, the summation sign can be replaced by the integration sign, and the mathematical integration can be made. Practically, it is generally found impossible to express these variables as continuous functions of x, and then make the integrations.

Usually, I is constant for short sections of the beam, in which case it is best to make successive summations for such sections, using the general form of the integration, with I constant, and making the limits correctly account for the variation in I for different sections. This method will now be illustrated by a practical example.

SECTION 11.—APPLICATION TO PLATE-GIRDER DRAW SPAN WITH VARIABLE MOMENT OF INERTIA.

As an example of the practical method of using the general Equation (41), and also in order to determine the effect of the variable moment of inertia, consider the following case of a plate-girder span continuous over three supports. This is the same girder as used by Johnson, Bryan, and Turneaure* to illustrate the use of a similar formula obtained by applying the principle of least work. It is used here in order to find how closely the results of the different methods agree.

Data for Girder.—$l = l_a = l_c = 60$ ft., that is, the total length $= 120$ ft. The girder is symmetrical about its center line.

The relative values of the moment of inertia, I, at the following distances from the outside ends, are:

0 to 12 ft., $I = 1$
12 to 36 ft., $I = 1.38$
36 to 48 ft., $I = 1.15$
48 to 60 ft., $I = 1.92$

The girder rests on all the supports, and has a straight horizontal neutral axis, therefore, $D_a = 0$, $D_c = 0$, sec. $\beta = 1$.

The end bending moments are zero, therefore, $M_a = 0$, $M_c = 0$.

Noting the fact of the constant, I, for the given sections, let x_1 and x_2 be the distances from the end of the girder to the beginning and the end, respectively, of a given section having a constant, I, and let $\frac{1}{I} = i$ for such section. Then, by substituting in the General Equation (41), there results, after multiplying through by l^2:

$$0 = M_b \left[\sum_A^B \int_{x_1}^{x_2} i\, x^2\, dx + \sum_C^B \int_{x_1}^{x_2} i\, x^2\, dx \right]$$
$$+ l \left(\sum_A^B i\, M_s\, x\, dx + \sum_C^B i\, M_s\, x\, dx \right) \ldots\ldots\ldots \quad (42)$$

---

* "Modern Framed Structures," Vol. II, p. 39.

For the case here considered, with a fully loaded beam carrying a uniform load, w lb. per ft., $M_s = \frac{w}{2} x\,(l - x)$. Therefore,

$$\sum i\,M_s\,x\,dx = \frac{w}{2}\sum\int_{x_1}^{x_2} i\,x^2\,(l - x)\,dx$$

$$= \frac{w}{2}\sum\left[\,i\,x^3\left(\frac{l}{3} - \frac{x}{4}\right)\right]_{x_1}^{x_2}$$

Then Equation (42) will give the following value for M_b:

$$M_b = -\frac{3\,wl}{2}\,\frac{\sum_0^l\left[\,i\,x^3\left(\frac{l}{3} - \frac{x}{4}\right)\right]_{x_1}^{x_2}}{\sum_0^l\left[\,i\,x^3\right]_{x_1}^{x_2}} \qquad \text{.........(43)}$$

The computation can best be made in the form shown by Table 1.

TABLE 1.—COMPUTATION FOR M_b.

6-ft. Sections.	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	
	x: x_1	x_2	I	i	x^3	$\left[i\,x^3\right]_{x_1}^{x_2}$		$\frac{l}{3} - \frac{x}{4}$	$\left[i\,x^3\left(\frac{l}{3} - \frac{x}{4}\right)\right]_{x_1}^{x_2}$	
						Columns 4 × 5			Columns 6 × 7	
1-2	0	12	1.0	1.0	x_2 1 730	1 730	......	17	29 400	
					x_1 0	— 0	1 730	20	0	29 400
3-4-5-6	12	36	1.38	0.725	x_2 46 700	33 700	......	11	371 000	
					x_1 1 730	— 1 200	32 500	17	— 21 000	350 000
7-8	36	48	1.15	0.87	x_2 110 600	96 000	......	8	768 000	
					x_1 46 700	—40 400	55 600	11	— 445 000	323 000
9-10	48	60	1.92	0.52	x_2 216 000	112 400	......	5	562 000	
					x_1 110 600	—57 400	55 000	8	— 460 000	102 000
						Σ = 144 800			Σ = 804 400	

Then, $$M_b = -\frac{3}{2}\,wl \times \frac{804\,400}{144\,800} = -\,8.34\,wl.$$

For the given case, $l = 60$ ft.:

Therefore, $M_b = -8.34 \times 60\, w = -500\, w$.

When I is assumed as constant, as in the usual form of the theorem, let $l_a = l_c = l$, and $w_a = w_c = w$, in Equation (35),

$$2\, M_b\, (l + l) = -2\left(\frac{wl^3}{4}\right), \text{ whence,}$$

$$M_b = -\frac{wl^2}{8} = \frac{-w \times 60^2}{8} = -450\, w.$$

The exact method, therefore, gives a value for M_b about 11% higher than the approximate method, using the constant, I. The method of least work* gave $M_b = -492\, w$, about 2% less than the value here found by the exact method.

To Derive the Maximum Limit for Error.—The error introduced by using the general form of the theorem of three moments in such cases of girders with variable I, carrying the uniform load, and symmetrical over three supports, can be shown to be about 15% for the limiting case where I is assumed to vary directly with M, that is, for a theoretically perfect design, which, of course, is a practically impossible case.

The reaction, R_a, can be found by locating the point of contraflexure where the bending moment changes sign, and noting that the end shears for the equivalent simple beam, between points of contraflexure or zero bending moment, can be found exactly as in simple beam analysis. For the foregoing case of two equal spans loaded with equal uniform loads, the tangent at the intermediate support, B, remains fixed and horizontal. Therefore, if x_0 = distance from A to the point of contraflexure:

$$[D_{va}]^l_0 = \int_0^l \frac{M\, x\, dx}{EI} = \int_0^{x_0} \frac{M\, x\, dx}{EI} - \int_{x_0}^l \frac{M\, x\, dx}{EI} = 0.$$

Now let $\frac{M}{I} = K$, substitute, and cancel the constants, $\left(\frac{K}{E}\right)$,

$$\int_0^{x_0} x\, dx = \int_{x_0}^l x\, dx$$

$$\frac{x_0^2}{2} = \frac{l^2}{2} - \frac{x_0^2}{2}. \quad \text{Therefore, } x_0 = \frac{l}{\sqrt{2}} = 0.707\, l.$$

(Note that $x_0 = 0.75\, l$, when I is assumed as constant.)

Then, $R_a = \frac{wx_0}{2} = 0.354\, wl$; and, $M_b = R_a\, l - \frac{wl^2}{2} = 0.354\, wl^2 - 0.5\, wl^2 = -0.146\, wl^2$.

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* As applied in "Modern Framed Structures," Vol. II, p. 40.

As shown before, the usual form of theorem, with I assumed as constant, gives for this case:

$$M_b = -\frac{wl^2}{8} = -0.125\ wl^2.$$

Therefore, the approximate method gives results which are too low by a maximum limit of 15% of the exact value, or 16.8% of the approximate value.

The general conclusion that the usual approximate formula will give M_b from 10 to 15% too low, when applied to girder spans with widely varying moments of inertia, seems to be quite justifiable, the effect of shear deflection being neglected.

Two cases of swing-bridge girders, with the variable, I, are solved by C. W. Hudson, M. Am. Soc. C. E., by the formulas derived from the method of deflections.[*] The first is a light single-track girder with two equal spans of 68 ft.; and the second is a heavy double-track girder with two equal spans of 78 ft. In the first case the center bending moment, M_b, is 15% greater, and in the second case 11% greater, by the exact method than by the approximate method. Mr. Hudson,[†] also computes the effect of shear deflection on the center bending moment, and finds, in the first case, a decrease of 2.6%, and in the second a decrease of 5%, as compared with the value obtained by neglecting shear distortion.

It is evident that the usual approximate assumption, neglecting the variable, I, and shear deflection, will introduce errors which tend to compensate each other. Especially is this true in the case of framed trusses, where the effect of shear distortion is relatively much greater. It has been found that the usual method of designing swing-bridge trusses, by the ordinary restricted formula, assuming I as constant and neglecting shear deflection, is justifiable, because the method of deflections, when applied to the resulting design, gives reactions which agree very closely with those found by the usual approximate method with the restricted form of the theorem of three moments. For plate-girder draw spans, however, the ordinary design formulas have been shown to introduce errors as large as from 10 to 12% on the side of danger, when the effects of variable moments of inertia are neglected.

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[*] "Deflections and Statically Indeterminate Stresses," pp. 49-50.

[†] *Loc. cit.*, pp. 54-55.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

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THE INFILTRATION OF GROUND-WATER INTO SEWERS.

By John N. Brooks, Jun. Am. Soc. C. E.

To be Presented February 5th, 1913.

An examination of the Index to the *Transactions* of the American Society of Civil Engineers, published recently, shows that the Society has never published a paper on the infiltration of ground-water into sewers. Some recently collected data on the subject are presented in Table 1, and a glance shows that the information is incomplete in most cases, and that there is a wide variation in the form in which it is presented.

The writer, therefore, has attempted to prepare a comprehensive and compact form for the presentation of data on infiltration, and to suggest rational units for the measurement of its quantity.

The factors governing the total quantity of infiltration into a sewer are:

1.—The diameter and length of the sewer.
2.—The material of which the sewer is constructed.
  a.—In vitrified pipe sewers, the type of joint used.
  b.—In concrete or brick sewers, the type and quantity of water-proofing used.
3.—The skill and care used in laying the sewer.
4.—The character of the materials traversed by the sewer.
5.—The relative positions of the sewer and the ground-water level.

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

TABLE 1.—Data on Infiltration of Ground-Water into Sewers.

Item No.	Place.	Diameter of sewer, in inches.	Length of sewer, in miles.	Leakage, in percentage of capacity of sewer.	Leakage per day per mile of sewer, in gallons.	Leakage per day per capita, in gallons.	Total leakage, in gallons, per day.	Remarks.
1....	Boston, Mass.	8 to 36	137		40 000	50	5 480 000	Before any connection to sewer.
2....	Massachusetts State	Various.	700		80 000	100	56 000 000	Densely populated section—800 people per mile of sewer.
3....	Kalamazoo, Mich.			20%				Before any connection to sewer.
4....	Norfolk, Va.			60%		100		
5....	Schenectady, N. Y.			5%				Wet ground and quicksand
6....	Canton, Ohio		11		26 500	*41	73 000	
7....	Taunton, Mass.	24		20%				Passing through swamp.
8....	North Brookfield, Mass.	12	0.3		17 000	71	2 500–5 000	
9....	Rogers Park, Ill.	6	1.7		1 240	*2	2 108	Deep sockets and careful ramming to minimize leakage.
10....	Brockton, Mass.		16		25 000	31	400 000	
11....	Altoona, Pa.	27 30 33¼ by 44	1.2 0.6 0.95		40 814 86 592 264 000	*65 *145 *442	47 181 52 352 252 342	Brick and concrete sewer. Leakage reduced after careful watching of contractor.
12....	East Orange, N. J.		29		22 400	*43	650 000	10 ft. or more under water. Quicksand. Great precaution to prevent leakage.
13....	East Orange, N. J.		25		8 700	*14	217 500	
14....	Joint Trunk Sewer		150	10%	25 000	25	3 750 000	Glacial drift and quicksand.
15....	Av. of Bloomfield, Orange, Montclair, and Glen Ridge					107	6 430 000	Average for the years 1895 to 1906.

* 600 people per mile of sewer.

Items 1 and 2. Report of State Board of Health. Discharge of Sewage into Boston Harbor. 1900.

" 3 to 12, inclusive. Report of F. P. Stearns, Past President, Am. Soc. C. E., on the Sewerage of Mystic and Charles Rivers. Jan., 1899.

" 13 and 14. *Engineering Record*, Vol. 62, Oct. 1st, 1910, p. 377.

" 15. Passaic Valley Sewerage Commission, Report of Dec., 1907, p. 13.

" 14. Joint Trunk Sewer. Takes in sewers of part of Elizabeth, Roselle Park, part of Newark, West Orange, Summit, etc.

Reference to Table 1 shows that in every case data on some of these factors are missing. As it is evidently impossible to express all these factors in precise terms, it becomes necessary to agree on such terms, and the writer suggests the following:

For the material of which the sewer is constructed, in the case of pipe sewers, use the term "Vitrified Pipe." In the case of concrete sewers, state the thickness of the wall, the mixture, and whether crushed stone, gravel, or slag was used in the aggregate. For brick sewers, state the thickness of the wall, the quality of the brick, and the bond.

The type of joint is usually easily described. If the joints are of cement, it should be noted whether they are finished with a bevel or flush with the bell of the pipe.

For the type and quantity of water-proofing, if a fabric is used, the percentage of the total length of sewer treated may be stated, together with the number of plys of fabric and the kind of paint. In cases where a water-proofing compound is mixed with the concrete, a statement of the kind and quantity of compound will be sufficient.

For skill and care used in laying, use such terms as "Little," "Ordinary," and "Unusual."

For the character of the materials traversed, use such terms as "Wet," or "Dry," "Rock," "Gravel," "Sand," or "Clay."

For the relative positions of the sewer and the ground-water level, reference may be made to the daily reports of the engineer or inspector; and the length of wet trench reported may be expressed as the percentage of the total length of the trench, assuming that where wet trench is reported the sewer will be below the ground-water level.

The foregoing descriptive terms will inevitably have different shades of meaning for different engineers, but the writer believes that they are sufficiently definite to present the salient features of a sewer described by them with a degree of accuracy sufficient for an intelligent comparison with other sewers.

Reference to Table 1 shows that there is a wide variation in the units chosen for the measurement of the quantity of infiltration, and that none of them is altogether satisfactory. Expressing the quantity of infiltration as a percentage of the maximum capacity of the sewer is irrational, because the maximum capacity depends in part on the gradient of the sewer, which has no relation whatever to the quantity of infiltration.

Gallons per day per mile of sewer is a useful unit only when the size of the pipe and the length of each size are stated, and in a collecting system with many laterals such a statement becomes decidedly cumbrous.

Gallons per day per capita of tributary population appears to be the favorite measure of the quantity of infiltration, but this unit is entirely irrational, for there is no conceivable relation between the number of people contributing sewage and the quantity of ground-water percolating into a sewer.

The total quantity of infiltration, in gallons per day, is a statement which is evidently entirely useless in making comparisons between systems unlike in diameter and length of conduit.

In view of the unsatisfactory form of the data, and of the units thus far considered, the writer suggests the presentation of such data in the manner shown in Table 2, and the following units for the measurement of the quantity of infiltration. These units are used by Mr. Nicholas S. Hill, Jr., and are believed by the writer to be both simple and rational.

For vitrified pipe sewers, the unit is gallons per day per foot of joint. Table 3 shows the total length of joints per 100 ft. of sewer for the commercial sizes of pipe, for which the total length of joints for any length of sewer is obtained by a single multiplication. Evidently, in a vitrified pipe sewer free from cracks, infiltration can occur only at the joints. An examination of Table 1 shows that sufficient data for the computation of infiltration, in gallons daily per foot of joint, are presented in only four cases, namely, Items 8 and 9, and in two sewers under Item 11. The data for these cases are repeated in Table 2, with the computed infiltration expressed in gallons per day per foot of joint; this is seen to vary from 0.3 to 5.0.

For concrete and brick sewers, the unit is gallons per day per square yard of interior surface. Table 4 shows the interior surface area, in square yards per 100 ft. of sewer, for circular sewers, from 3 ft. 8 in. to 6 ft. in diameter, and a single multiplication gives the interior surface area for any length of sewer. For sewers of egg-

TABLE 2.—DATA ON INFILTRATION OF GROUND-WATER INTO SEWERS.

Item No.	SEWER.								Wet trench; percentage of total length.	Character of material traversed.	INFILTRATION, IN GALLONS PER DAY.	
	Place.	Type of section.	Material.	Diameter.	Length, in feet.	Skill and care in laying.	Type of joints.	Water-proofing; type and percentage of total length.			Per foot of joint.	Per square yard of inside surface.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
8	North Brookfield, Mass.	....	....	12 in.	1 584	....	....	....	......	....	2.0	....
9	Rogers Park, Ill. ..	....	....	6 “	8 976	Unusual..	Deep sockets.	....	......	....	0.3	....
11	Altoona, Pa.	....	....	27 “	6 336	....	....	....	......	....	2.6	....
	“ “	....	....	30 “	3 168	....	....	....	......	....	5.0	....
16	....	Circular	Reinforced concrete, stone or gravel, 1 : 2 : 4.	3 ft. 8 in.	2 462	Ordinary.	....	3-ply felt and pitch, 4 per cent.	80	Wet and dry gravel.	....	0.8
		“	“	4 “ 3 “	7 220	“	....	“	“	“	....	
		“	“	4 “ 4 “	1 904	“	....	“	“	“	....	
		“	“	4 “ 6 “	11 066	“	....	“	“	“	....	
		“	“	4 “ 9 “	5 838	“	....	“	“	“	....	
		“	“	5 “ 0 “	3 574	“	....	“	“	“	....	
		“	“	5 “ 3 “	2 901	“	....	“	“	“	....	
		“	“	6 “ 0 “	12 779	“	....	“	“	“	....	

shaped or basket-handle cross-section it is necessary to compute the circumference for the special sections involved, but these computations will have been made in the design of the sewer long before the engineer is ready to make infiltration tests.

TABLE 3.—Vitrified Pipe.

Nominal diameter, in inches.	Laying length, in feet.	Length of each joint, in feet.	Length of joint per 100 lin. ft. of sewer, in feet.
(1)	(2)	(3)	(4)
4	2	1.05	52.5
6	2	1.57	78.5
8	2	2.09	104.5
10	2	2.62	131.0
12	2	3.14	157.0
15	2	3.93	196.5
18	2	4.71	235.5
21	2	5.50	275.0
24	2	6.28	314.0
27	2½	7.09	283.6
36	2½	9.42	376.8

TABLE 4.—Circular Sewers.

Diameter.	Inside area per 100 lin. ft., in square yards.
(1)	(2)
3 ft. 8 in.	127.99
4 “ 0 “	139.63
4 “ 3 “	148.35
4 “ 6 “	157.08
4 “ 9 “	165.81
5 “ 0 “	174.53
5 “ 3 “	183.26
5 “ 6 “	191.99
5 “ 9 “	200.71
6 “ 0 “	209.44

Item 16 of Table 2 gives the results of a test for quantity of infiltration, recently made by the writer, under the direction of Mr. Hill, on a new reinforced concrete trunk sewer. Triangular weirs were set at two points, 47 745 ft. apart, and each weir was provided with an automatic head-recording device, giving a continuous record of change in head, and reading to the nearest $\frac{5}{1000}$ ft. From these records the average head on each weir for a period of one week was computed, by obtaining with the planimeter the area between the curve of change in head and an arbitrary base line, and dividing by the proper length. From this average head the corresponding average rate of discharge was computed, making allowance for velocity of approach. The average time of flow between the weirs was obtained by the comparison of maxima and minima points on the respective curves showing decided change of head.

The interval or lag between the time of corresponding discharges having been determined as described, the total discharge at the up-stream weir for a period of one week was then subtracted from the total discharge at the down-stream weir during the corresponding period. The difference in discharge thus determined is a very close measure of the quantity of infiltration between the weirs during one week. The conditions for this test were ideal, as no sewage entered the trunk lines between the weirs during the test. The infiltration found was at the rate of 0.8 gal. per day per sq. yd. of interior surface.

A careful inspection of the length of sewer tested revealed no visible cracks, and the work in general appeared to be first-class, but the quantity of infiltration measured appears to be much smaller than may in general be expected in work of this class.

The writer hopes that discussion of this paper may bring out improvements in the form suggested for the presentation of data on the infiltration of ground-water into sewers, as well as additional data on the subject.

He wishes also to acknowledge his indebtedness to Mr. Nicholas S. Hill, Jr., for valuable criticism and suggestion in the preparation of this paper.

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A SUGGESTED IMPROVEMENT IN BUILDING WATER-BOUND MACADAM ROADS.

By J. L. Meem, Esq.

To be Presented February 19th, 1913.

In this era of vast road building throughout the country, it has seemed to the writer that there is too much variance in the specifications, especially in those for water-bound macadam roads, and this paper describes what is believed to be an improvement in such road construction.

By way of explanation, it may be stated that water-bound roads are those in which the only binder is water, and this is used very plentifully in the process of building the road. There is no other foundation than the rolled earth; the standard depth of loose rock ordinarily used is 9 in., and when this has been thoroughly rolled, a theoretical depth of 6 in. of finished roadway is obtained. The ordinarily accepted specification for placing this rock calls for 6 in. of No. 1 stone (the largest size) varying from 1½ to 3 in. in diameter; then 2½ in. of No. 2 stone, varying from ½ to 1½ in. in diameter, and the top course is finished off with stone ½ in. and less in diameter, usually called "screenings," including the material resulting from the dust of fracture. Assuming, then, a depth of loose rock of 9 in. as a standard, the writer describes herein a method of proportioning this rock which he has used successfully and is using at the present time on an 8-mile section of the Memphis-Bristol Highway, in Tennessee.

Note.—These papers are issued before the date set for presentation and discussion. Correspondence is invited from those who cannot be present at the meeting, and may be sent by mail to the Secretary. Discussion, either oral or written, will be published in a subsequent number of *Proceedings*, and, when finally closed, the papers, with discussion in full, will be published in *Transactions*.

All road builders, both engineers and contractors, will probably agree that the difficult and the essential thing to obtain in a water-bound road is the bond, and the method herein described attains this result at probably less cost than any other, and certainly at very much less cost than any the writer has ever tried.

The method consists in separating the screenings into two sizes, one size being from ½ to ¼ in. and the other the dust of fracture, and putting these two sizes on the road in separate operations, and the writer wishes to suggest the adoption of the following specifications for building a water-bound macadam road, both as to the method of proportioning the rock and as to sprinkling:

(*a*) The sub-grade shall be thoroughly rolled until it is firm and compact, with the proper crown of ¾ in. per ft.

(*b*) On this shall be placed 6 in. of No. 1 grade rock, ranging in size from 1½ to 3 in. This shall be spread uniformly and rolled dry until the rock does not creep before the roller, or creeps just enough to set it in place without crushing.

(*c*) Then 2 in. of stone of No. 2 grade, ranging in size from ½ to 1½ in., shall be spread uniformly, sprinkled, and rolled thoroughly into the voids of the No. 1 grade.

(*d*) Then ¾ in. of the coarse material from the screenings, consisting of sizes from ¼ to ½ in., shall be spread uniformly, sprinkled, and rolled thoroughly into the voids of the No. 2 grade.

(*e*) Finally, ¼ in. of the dust from the screenings shall be spread (preferably by hand from shovels), thoroughly soaked, and rolled to a finish.

This method gives a surface which is virtually impervious to water, and is less affected by automobile traffic than any with which the writer has had experience; in fact, it has been a matter of great surprise to him to see how well roads built by this method withstand automobile traffic without "raveling" or showing signs of deterioration.

From the contractor's point of view, as an economical method of building macadam roads, the writer finds that on the Memphis-Bristol Highway he is able to care for 100 cu. yd. of rock per day with one 10-ton roller, where previously, before the change was made, there was some difficulty in rolling properly one-half this quantity and getting the proper bond therein, in spite of the fact that it requires one more operation to put on the extra course of stone. This is very much more than balanced by the quicker method of obtaining the required bond, and the final results as stated are so much more satisfactory than those obtained by using only three grades of rock and not separating the dust from the screenings that it would seem to be a material improvement in the method of road building, and should appeal to both engineers and contractors. It is only fair to say that the specification under which this section of the Memphis-Bristol Highway is being built called for the placing of the macadam in three operations, as originally stated, but that the change has been approved by the engineer in charge who now highly endorses the method.

This work requires a standard screen with a “dust jacket” ($\frac{1}{4}$-in. perforations) over the $\frac{5}{8}$-in. screen.

The writer, who is a member of the contracting firm which is building this section of the road, is interested both from the standpoint of the engineer and the contractor. He has never before seen this method advocated publicly, and invites discussion and criticism from other road builders.

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ON LONG-TIME TESTS OF PORTLAND CEMENT.

By I. Hiroi, M. Am. Soc. C. E.
To be Presented February 19th, 1913.

The behavior of Portland cement in sea water has long been a subject of discussion by chemists and engineers; yet the lack of complete experimental data on one hand and vast amounts of material and labor placed at stake in most harbor works of magnitude relying on the durability of cement, on the other, seem to make any results of investigation on its nature a matter of ever recurrent interest, especially to those engaged on maritime works. It is under such an impression that the writer presents some of the results of his still unfinished experiments, the completion of which, however, he may not live to see.

More than 15 years ago, at a time when the writer had to give out instructions for manufacturing concrete blocks for use in harbor works, he commenced a series of tests on the behavior of the cements then in use, in order to ascertain as far as possible the reliability of the rules laid down for the execution of the works. The tests have included the quantity and quality of water used in gauging, the quantity and quality of the sand and ballast, the differences of temperature, the kind of surroundings, the modes of fabrication, and, in short, most of the important points in the manufacture of mortar and concrete considered likely to affect the strength of finished work in course of time. Most of these tests have confirmed the correctness

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of the method as found in treatises relating to the subject and generally practiced in good works, so that it is hardly worth while describing here the results obtained. The durability test alone seems to be of some interest, particularly to those who have doubts as to the permanence of cement structures built in sea water.

The tests have been proposed to extend over 50 years, and although the time which has elapsed hardly covers one-third of that period, the results thus far obtained are of some value in showing the general trend of changes taking place in the strength of cement, and in forecasting in a certain measure the eventual results of the tests.

Three different kinds of cement and one hydraulic lime have been used for the various tests. In this paper only the results obtained with two kinds of cement will be considered. The chemical analyses of these two cements are given in Table 1.

TABLE 1.—CHEMICAL ANALYSES OF CEMENTS.

	CEMENTS.	
	A	*B*
Loss by combustion	0.88	1.24
Insoluble matter	1.30	1.25
Silica	22.20	19.00
Alumina	7.55	8.35
Ferric oxide	2.90	3.90
Lime	61.77	62.17
Magnesia	1.12	1.75
Miscellaneous	2.28	2.34

In quality, the cements satisfied the following requirements:

The cement shall be so fine that the residue on a sieve of 5 000 meshes per sq. in. will not exceed 10% of the whole.

The quantity of alumina contained in the cement shall not exceed 3 per cent.

The cement shall hot commence to set within 1 hour of mixing with water.

The cement in setting shall not show any change in shape or volume.

Briquettes composed of 1 part of cement and 3 parts of standard sand, and immersed in sea water, shall have a tensile strength of not less than 130 lb. per sq. in. after 1 week, and gradually increasing to 170 lb. in 4 weeks, the amount of that increase to be not less than 30 lb. per sq. in.

All the briquettes for the durability test were made by hand, the mortar being gauged with fresh water and struck into the mould (with a trowel weighing 1¾ lb.) until water rose to the surface. The briquettes thus made were placed in a covered box for 24 hours, after which they were transferred to several media. The sands used for the mortar were of two kinds: (1) Coarse beach sand, with grains of all sizes up to about 0.06 in.; and (2) standard sand obtained by sifting the coarse sand between sieves with 400 and 1 400 meshes per sq. in. The briquettes kept in air were placed in an open shed, and those in water in tanks in which the water was changed once a week. The briquettes are uniformly 1 sq. in. in section, and five of them have been taken out for each single test.

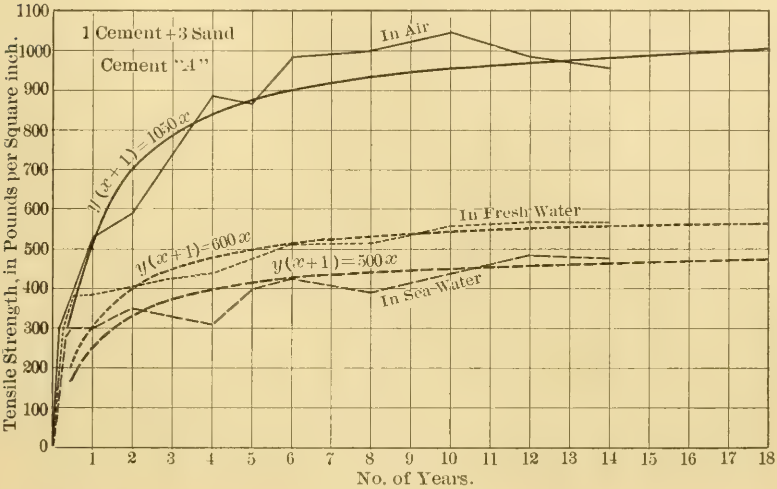

FIG. 1.

Fig. 1 shows the results of tests made with a mortar of 1 cement and 3 sand, by weight. These briquettes were placed separately in air, fresh water, and sea water, 24 hours after fabrication, in the manner already described, and remained there until tested. The strengths of briquettes made with coarse and standard sands have been found to be so nearly alike that the mean results were taken in plotting the curves. The strength attained by the use of finer sand naturally came out considerably lower. It will be seen, as might have been anticipated, that the mortar attains the greatest strength in air and the least in sea water, the mean comparative ratio of strength attained being nearly as follows:

Air	1.00
Fresh water	0.56
Sea water	0.45

The curves of strength thus traced are approximately hyperbolic, and may be more or less closely expressed by the following equations:

$$\text{In air} \ldots\ldots\ldots\ldots y = \frac{1\,050\,x}{x+1}$$

$$\text{In fresh water} \ldots\ldots y = \frac{600\,x}{x+1}$$

$$\text{In sea water} \ldots\ldots\ldots y = \frac{500\,x}{x+1}$$

in which $y =$ the tensile strength, in pounds per square inch, and $x =$ the number of years elapsed.

It will be seen that such mortars attain their greatest strength in about 6 to 10 years, beyond which, although they still continue (through occasional ups and downs) to increase in strength, the rate of increase is inconsiderable.

With neat cement briquettes (Fig. 2), the results are entirely different. Those kept in sea water attain their greatest strength in about 2 to 10 months, after which they rapidly decline, in some cases completely losing their strength in 4 or 5 years. Even then, however, not only are their forms intact, but they also show considerable crushing strength, which may amount to more than 6 000 lb. per sq. in. In the case of hydraulic lime placed in sea water, neat briquettes begun to show signs of disintegration from the outside, in about a year, and after about 4 years even the sound core, which had been decreasing in size all that time, finally succumbed, leaving a shapeless mass. In air and fresh water, neat briquettes continue to increase in strength for 4 or 5 years, when they attain much higher strength than those placed in sea water. A comparison of the air curves on Figs. 1 and 2 shows the decided superiority, in the long run, of the use of 1 cement + 3 sand mortar over neat cement. The total loss of tensile strength in neat cement briquettes, whatever may be the medium in which they are placed, appears to be a question of time.

Fig. 3 shows another series of tests made with briquettes which had been kept immersed in fresh water for 2 months before they were finally

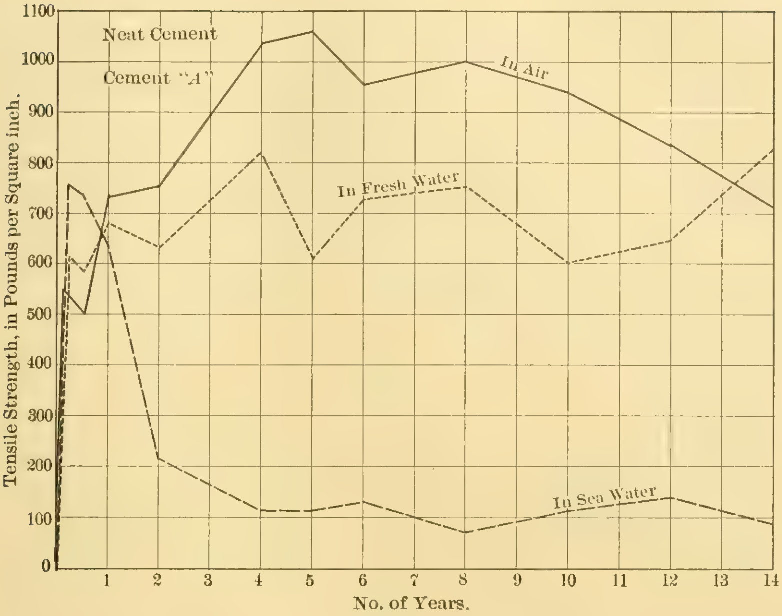
Neat Cement
Cement "A"
In Air
In Fresh Water
In Sea Water
Tensile Strength, in Pounds per Square inch.
0
100
200
300
400
500
600
700
800
900
1000
1100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
No. of Years.

Fig. 2.

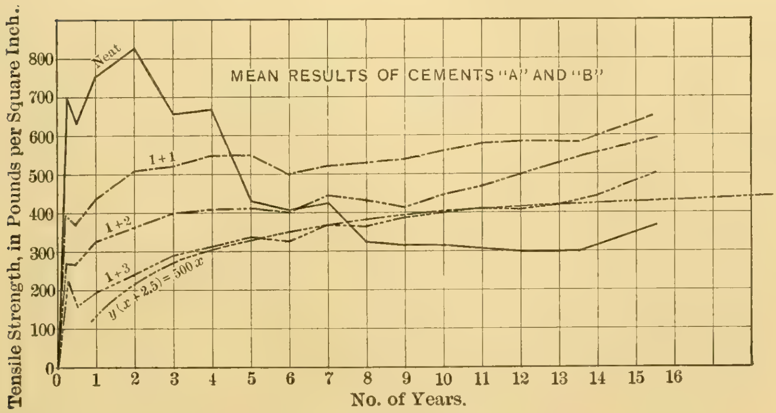
MEAN RESULTS OF CEMENTS "A" AND "B"
Neat
1+1
1+2
1+3
y (x + 2.5) = 500 x
Tensile Strength, in Pounds per Square Inch.
0
100
200
300
400
500
600
700
800
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
No. of Years.

Fig. 3.

placed in sea water in partial reproduction of the conditions which obtain with concrete blocks used in sea water. The briquettes are of neat cement, and of mortars of 1 cement + 1 sand, 1 cement + 2 sand, and 1 cement + 3 sand, all by weight. Each curve shows the mean of the results obtained for *A* and *B* cements. Although the general form of the curves, except that for the neat cement, are (as before) approximately hyperbolic, the increase of strength is not as rapid as in the case of briquettes immersed directly in sea water, shown in Fig. 1, but the rise is more steady and continues much longer. In the case of the 1 cement + 3 sand mortar, the regular curve given by the following equation approximately coincides with the actual one through the greater part of its length:

$$y = \frac{500\,x}{x + 2.5}.$$

As far as the comparison of this equation with the corresponding one in the preceding case bears out, the strength apparently attainable by such mortar appears to have the same limitation. With neat cement briquettes, the time in which the maximum strength is attained in this, compared with the previous case, is considerably retarded, taking place in about 2 years; and the rate of decline in strength is also much less rapid.

Although the results of these tests are not yet conclusive as to the permanence of strength of cements, their indications are that, with proper selection of materials, right proportions of ingredients, and with due attention to the mode of fabrication, cement mortars used under circumstances in which engineering structures are commonly built, will continue to increase in strength for indefinite lengths of time, and thus artificial stones made with them will be as enduring as natural ones of approved qualities.

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STREET SPRINKLING IN ST. PAUL, MINN.

Discussion.*

By C. L. Annan, M. Am. Soc. C. E.†

Mr. Annan.

C. L. Annan, M. Am. Soc. C. E. (by letter).—In reply to Mr. Whinery, the following statement of unit costs is presented:

Total travel of 80 teams per day......	5 248 000	lin. ft.
Total effective travel (76%)..........	3 883 520	" "
Total area (width of spray, 22 ft.)....	9 493 050	sq. yd.

Daily expense:

80 teams @ $100 per month........................	$267
10 inspectors @ $75 per month..................	25
Stand-pipe repairs, average.......................	15
Sprinkler " "	13
2 000 000 gal. water @ $90.........................	180
Total	$500

Consequent cost of sprinkling 1 sq. yd. once. .0.00527 cent.
Average cost of sprinkling 1 sq. yd. four times per day for 210 days..................4.4 cents.

During the summer of 1910, 80 000 gal. of a 45% liquid asphalt, heated to 150° Fahr., were applied to 300 000 sq. yd. of macadam surface, the cost per square yard being as follows:

Cleaning street surface.......................	0.35	cent.
Road oil..................................	1.00	"
Application	0.15	"
Total	1.5	cents.

Three applications would be required for the full season, which would make the cost practically the same as for water sprinkling.

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* Continued from November, 1912, *Proceedings*.

† Author's closure.

Mr. Annan. There was much opposition and complaint of damage and annoyance by residents along the smeared streets, however, and, furthermore, as the oil dried out, it left the street surface in a badly disintegrated condition. During the following year a 20% oil was used. No heating was required; and three applications were sufficient for the season. The surface damage was less, but the popular outcry was not much abated.

In making the assessment, the factor of street widths is provided for in the trip element. Three trips are necessary to cover some wide streets; one trip suffices for a narrow street. The same frontage is assessed three times as much in one case as in the other, as a trip is a single line of travel in one direction.

The total cost of the season's sprinkling is prorated to the frontage participating. The law provides that 10% of this cost may be for equipment. The sprinkling of street intersections must also be regarded as a general charge, as there is no provision for payment otherwise. The law has also been construed to prohibit rebates for corner lots abutting on two sprinkled streets.

The matter of the concealed hydrant received attention early in 1910. Neither of the two eastern manufacturers approached could furnish just what was wanted, and it was late in the season before the desired article was obtained. In the meantime, the conclusion had been reached that the main objection to the stand-pipe is not its unsightly appearance. The ungainly sprinkler itself is no more esthetic, but worst of all is the faithful but inconsiderate horse at his 5 to 10-min. stands.

The teamster would view the innovation with no favorable eye. He would consider it a hardship to be forced to descend and climb again whenever he filled his tank, to say nothing of lifting the hydrant cover off and putting it on, and of stowing his loaded hose. The new hydrant was never put in.

The mud at the base of the stand-pipe, of course, must be eliminated as soon as possible by draining and paving, to insure the departure of a free tank.

When the St. Paul pavements are bare in freezing weather they are sprayed with calcium chloride (1 lb. per gal.) dissolved with a steam jet.

The following figures are approximately correct for a period of 3 weeks in December, 1910:

27 tons calcium chloride @ $14	$378
8 tons coal @ $4.75	38
4 teams, 18 days, @ $4	288
3 men, 18 days, @ $2	108
Total	$812

At intervals during the period, 100 000 sq. yd. of pavement were treated. Mr. Annan.

Mr. Blanchard asks: "If pavements are properly cleaned, * * * is there any necessity to sprinkle them to lay the dust? The answer is in the negative * * *."

Another answer is that the use of methods commonly considered effective does not down the demon "dust." Until perfection of method can be more nearly reached, a little water must be used here and elsewhere. Hand sweeping by day and power flushing by night and day do not hold dust in subjection. It is unceasingly making. It is tracked and blown in from adjoining unpaved streets, and arises from the sites of building operations. Whatever the theory, the condition must be met.

A light oil, especially designed for use on pavements, was tested last year on asphalt, brick, and stone surfaces in St. Paul, but with unsatisfactory results.

The vacuum cleaner may eventually do away with the use of the universal solvent, but it will be necessary to apply it to the sidewalks as well as the roadways, and even then will it get the impalpable, harassing dust emanating from all sources of friction in the busy life of a city's streets?

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THE STRENGTH OF COLUMNS.

Discussion.*

BY MESSRS. J. O. ECKERSLEY, HENRY S. PRICHARD, AND J. S. BRANNE.

J. O. ECKERSLEY, M. AM. SOC. C. E. (by letter).—This brief discussion of Mr. Lilly's suggestive paper was prompted by the question: Would it not repay the endeavor to derive a more rigorous treatment for the strength of columns? Science is truly a function of the epoch in its ideals and achievements, and technical knowledge, as we understand it to-day, is becoming pre-eminently mathematical, and justly so, for mathematics unchallenged governs the appreciation and mastery of the physical sciences in theory and practice. Mr. Eckersley.

Even though one has the feeling that the solution, in an absolute sense, founded on abstract mathematical reasoning, will be found impossible; at the same time, one recognizes the importance of the endeavor to attain precisely this result.

Although the demands made on mathematical science, to follow Mr. Lilly's paper, are not great, yet, if the rough and ready reasoning of the engineer gave way to the more rigorous analysis, a considerable knowledge in the realm of higher mathematics would be required.

In general, engineers, almost unanimously, regard analyses involving higher mathematics as dispensable. Judging from past experience, however, there appears to be every inducement for the mathematical engineer to continue his studies with unflagging zeal and confident optimism, for there is little reason to doubt, and many reasons to expect, greater achievements through just such persistent pursuit of scientific investigation.

This attitude of engineers toward analyses is clearly shown in their endeavor to simplify everything, an endeavor economically and entirely commendable, which, however, introduces simplifying assump-

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* Continued from October, 1912, *Proceedings*.

Mr. Eckersley.

tions such that it is questionable whether we may with propriety consider them valid, at least from a mathematical viewpoint.

The syncopation, we might say, of the column formula is no exception. For instance, Rankine's, written in the form, $y = a\ (1 + bx^2)^{-1}$, is a cubic equation; this was simplified to a quadratic by substituting a parabola in the form of $y = c - dx^2$; and, in due time, it was further reduced to the linear form, $y = e - fx$, where the letters, a to f, inclusive, represent empirical constants determined in every case as if the simplifying assumptions of the theory of flexure, initial straightness, homogeneity, central loading, etc., were rigorously obtained. The questioned validity of the deductions from such formulas is shown by the fact that the results of experiment and the deductions are not confirmatory. More exact mathematical treatment of the question than that given by the above formulas has been advanced by several writers, English, French, German, and American; also, the effects of eccentricity and local bending between points of attachment of lattice bars are not new. Mr. Lilly's treatment of the subject, in common with others, has introduced approximations at divers places in the analysis, which permit of criticism from the mathematical standpoint.

To compare some of the salient points of difference between what we may term the rigorous, as compared with the usual, approximate treatment, let us consider the following parallel columns for reference:

Rigorous.	Usual Approximation.
1st. When a column is subjected to strain, its dimensions in every direction are altered, the lateral changes following a law similar to that of Hooke.	1st. Changes of dimensions are construed as negligible.
2d. Strains do occur in all the three mutually perpendicular planes of reference.	2d. The strains are assumed to be entirely co-planar, *i. e.*, in one plane.
3d. A torque would, in general, exist.	3d. Irrotational stress is assumed.
4th. The elastic curve, when the column weight is considered, is not a symmetrical curve.	4th. The weight of the column is neglected, which leads to a symmetrical elastic curve.
5th. With suitable lateral forces, the so-called neutral plane may be broken or even discontinuous.	5th. So far as the geometry of the neutral line is concerned, it is regarded as a continuous curved line having a tangent and osculating plane.

Mr. Eckersley.

Rigorous.	Usual Approximation.
6th. The curvature would, in general, be tortuous.	6th. In the curvature formula, it is assumed that $dl = dx$, which reduces the exact expression, $-\frac{dx\,d^2y}{dl^3}$, to $\frac{d^2y}{dx^2}$. (Where the curve is such that a great difference in x occurs for a small difference in y, the exact form should be retained.)
7th. The section after strain is actually curved.	7th. The section is assumed to remain plane.
8th. Vertical shear-deformation exists.	8th. Vertical shear-deformation is neglected.
9th. The conjugate effect of transverse strain really transforms the surface of a rectangular sectioned column into an anticlastic surface.	9th. Conjugate effect of transverse strain is neglected.

To examine the column by the more exact treatment, recourse must be had to the general equations of the equilibrium of an elastic solid, and would lead to expressions involving determinants, elliptic functions, Bessel equations, and what not, and is beyond the scope of this discussion. The column would be introduced by definition, endowed with certain ideal properties, and subjected to certain conditions not confined to empiric verification, just as a set of necessary and sufficient axioms is adopted for the various geometries, and the translation, into the language of the applied mathematical treatment, would be accomplished by substituting as many of the properties of the materials as could be experimentally determined or inferred, in lieu of the ideal.

The essential difference between such an analysis and the usual method is that evanescent quantities of a higher order would be retained and their final elimination made when the derivative governing the desired degree of accuracy was determined; while the usual method neglects certain factors in the initial assumptions and later approximations, believing that their effect on the final result is negligible, which, of course, is admissible when the degree of approximation permits, that is, when the displacements are expressed as functions of some selected system of spatial co-ordinates and are developed into series—the approximation ends with the first derivative, and we have the usual Hooke's assumption, of a plane remaining plane under strain. This order of accuracy, however, is only an approximation; yet, under certain conditions, it is sufficiently close.

Mr. Eckersley.

What the writer wishes to bring out clearly is this: A vast literature has developed on the subject, both at home and abroad, and nowhere has he found what could be called a rigorous solution from the purely "mathematical theory of elasticity" point of view. The question in mind while writing this is: Would it not be profitable to attack the problem from such a point of view, and then use this as a means toward the interpretation and co-ordination of the phenomena? What if the analysis does involve the theory of probabilities, determinants, and higher functions? It is the pursuit along these lines which offers any reasonable excuse to engineers for the existence of anything other than a straight-line formula; for the problem from an engineer's point of view is simply this: Primarily, for very short prisms (so short that no lateral forces act), the crushing strength represents the value of the function. Secondarily, for very long prisms, in general (even though lateral forces act), the bending value is the controlling factor, and represents the function. Hence, all that the engineer desires is a rational formula giving a continuous relation between these two limiting values, even though it contains approximations.

It is obvious how complex the relations between the crushing, shearing, and bending values of the material would be for intermediate lengths, aside from the influence of local bending due to lattice bars, etc. The true form of the expression involving these would be of little interest save to the mathematical engineer, for it must be conceded that, from a practical point of view, a straight-line formula can be used successfully in the design of columns.

Finally, Mr. Lilly is to be congratulated and encouraged to continue his investigations, which will, it is believed, approach more nearly the more rigorous treatment as he considers the neglected factors.

Mr. Prichard.

HENRY S. PRICHARD, M. AM. SOC. C. E. (by letter).—The author considers the Rankine-Gordon formula to be the best of the various formulas which have been put forward to determine the strength of columns, and in support of his opinion he quotes the statement that: "The theoretic basis of Rankine's formula seems far more satisfactory than that of any other which has been proposed"; but he qualifies his opinion in respect to "theoretic basis," by stating that an assumption is made in the derivation of the formula which "errs on the side of safety."

In dealing with the practical side of his subject, the author gives, in Fig. 4, a curve, *A*, showing the results of some tests which he made on mild-steel solid columns, ½ in. in diameter, and another curve showing the results obtained by using Rankine's formula with constants, which he, the author, has deduced for mild steel; and he states that he "has shown that the experimental curves can be closely approximated

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by assuming the deflection curve of the column to vary in some proportion less than the square of the length"; that "the resulting formulas then become more complex and are of little use for the practical design of columns," and that "for this reason" he "adheres to the Rankine-Gordon as a practical working formula."

In this comparison of the Rankine-Gordon formula with the results of experiments, the constant used as "the strength to compression" is 80 000 lb. per sq. in. The writer does not share the author's opinions as to the theoretical and practical excellence of the Rankine formula, and he does not approve of the use of such a high unit stress for "the strength to compression."

Rankine, before giving his analysis of beams and columns, states that "the elasticity of every solid is sensibly perfect when the strain does not exceed a certain limit," that "Hooke's Law—'*ut tensio sic vis*'—is sensibly true for all relations between strains and stresses," and that "this condition is fulfilled in nearly all cases in which the stresses are within the limit of proof strength"; and he bases his analyses on these fundamental statements; in other words, he predicates ideal conditions.

In his analysis of beams, he derives equations for deflections based on the fact—quite true for beams—that the entire stress in the extreme fiber is due to bending. Subsequently, he makes the mistake of applying one of these equations to the deflection of columns, entirely overlooking or neglecting the fact that, in all cases of ordinary columns, part, at least, of the stress in the extreme fiber is due to direct compression. This mistake leads to an erroneous formula for columns, which, on the strength of Rankine's endorsement, has deceived and has continued to deceive engineers, and interfere with a correct understanding of the subject, for more than fifty years.

The error is reflected in the author's Equation 6 for deflection of columns, which he makes a factor of the total stress intensity in the extreme fiber f, instead of a factor of $f - p$, as it should be (p being the load per unit area). The author prefaces this substitution with an unwarranted assumption, which, as he states, "errs," and gives what he terms "the first approximation." When f has a value of 80 000 lb. per sq. in. and the length is 60.8 times the radius of gyration, the effect of this substitution is to change the result of his Equation 7 from 80 000 to 40 000 lb. per sq. in.

It is astonishing that Rankine should have made, or acquiesced in, this error in regard to the deflection of columns, as a centrally loaded column, made of perfectly elastic material and having an initially straight axis, is truly a spring, and he has proved the following:*

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* "Applied Mechanics," Eleventh edition, pp. 351–352.

Mr. Prichard.

"THEOREM. *That a spring of a given length and section, to the ends of whose neutral surface a pair of forces are applied, will not be bent if those forces are less than a certain finite magnitude.*"

He develops the equation, $P = \frac{\pi^2 E I}{l^2}$ (which is Euler's), and adds, "and this *finite quantity* is the *smallest force which will bend the given spring* in the manner proposed." For instance, a centrally loaded, perfectly elastic, initially straight spring, with a modulus of elasticity of 30 000 000 and a ratio of length to radius of gyration of 60.8, will not be bent if the load is less than 80 000 lb. per sq. in.

There is another limit to the value of P; it cannot, of course, be greater than $f A$ (limiting stress intensity times cross-sectional area), and this latter limit governs for short columns, as the force required to strain such columns to the limiting stress intensity is less than that which it would take to bend them, if they were not thus limited. For instance, if a steel spring be conceived as having a ratio of length to radius of gyration of less than 60.8, and if the limiting stress intensity is 80 000 lb. per sq. in., the stress will reach this limit under a load of 80 000 lb. per sq. in. without any preliminary bending.

In view of the prevalent uncertainty as to the theory of perfectly elastic, initially straight, centrally loaded columns, the writer suggests that the author state whether he accepts this theorem of Rankine's; and if he does not accept it, that he indicate wherein he considers Rankine's "proof" to be in error.

For the limiting stress intensity given by the author (80 000 lb. per sq. in.), the limiting line, on Fig. 4 (beyond which initially straight, perfectly elastic, mild-steel columns will either crush or become plastic and flow, if short, or begin to bend and almost immediately fail,* if long), will follow the 80 000 lb. per sq. in. line from $\frac{l}{\rho} = 0$ to its intersection with Euler's curve at $\frac{l}{\rho} = 60.8$, and from this point it will follow Euler's curve for all longer columns. The difference between this theoretically correct line and the line, Curve *2*, of the author's adaptation of Rankine's formula, shows the latter to be in error as a theoretical formula, for such ideal steel under such ideal conditions, from 0 to 50 per cent.

Of course, steel which crushes at 80 000 lb. per sq. in. is not perfectly elastic to this limit, and, of course, the other ideal assump-

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* In a paper on the "Theory of the Ideal Column," in *Transactions*, Am. Soc. C. E., Vol. XXXIX (1898), pp. 100–102, William Cain, M. Am. Soc. C. E., has shown: "first, that Euler's formula gives the load at which bending just begins, and, second, that a very small increase to this load insures failure." As a numerical illustration, a column pivoted at the ends. 325 in. long, was assumed as built up of two 5-in. channels. The inch being the unit, $A = 3.9$, $I = 14.8$, and $E = 29\,000\,000$ lb. per sq. in. Euler's formula gives the load that causes incipient bending as 40 105 lb. It was computed by an exact formula that an increase of the load of only 5 lb. caused a deflection of 3.44 in. at the center, with a resultant stress on the most compressed fiber greater than the elastic limit. Finally, an increase of 2 or 3 lb. more would entail rupture, or a breaking in two of the column.

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tions of theory are not fully realized. Actually, columns are never quite initially straight and centrally loaded. There is always some initial deviation between the axis and the line of thrust (though it is not always appreciable), and this causes some deflection under any load, though in many cases it is very slight and in some it is not appreciable until the load is nearly equal to either Euler's limit, if the column is long, or to the yield point, if it is of moderate length.* Actually, the limiting stress at which failure occurs, in wrought-iron and steel columns which are too short to have Euler's formula apply, is not constant (even for material of the same quality), as indicated by theory, but varies from a stress somewhat below the yield point, for the longest columns of this class, to the yield point, for short columns, and to the crushing stress for very short ones. This is due to the great reduction in stiffness which takes place at the yield point and to the partial reduction in stiffness from imperfections in elasticity, which develops shortly before the yield point is reached.

The loss in stiffness necessary to cause failure by bending grows less as length increases; hence, the load required to cause the failure of columns of this class grows less as length increases, even when great care is taken to reduce to a minimum the initial deviation between the axis and the line of thrust.

The fact that the strength of wrought-iron and soft or medium steel columns of moderate length is limited to about the yield point, is well illustrated in Tables 2 and 3, and many other series of column tests could be cited if necessary. In fact, the writer does not know of any such columns of moderate length which sustained loads greater than the yield point of the material. In experiments, short columns, solid or of thick material, do, temporarily, at least, sustain loads in excess of the yield point, and their ability to do so has a value as a temporary safeguard against disaster under excessive loads, even though the columns would be irreparably injured. This justifies a somewhat higher working load for such columns than would otherwise be the case.

Short wrought-iron and steel columns of such solid or thick material, however, are not much used. Most short columns are made of such thin material, have their cross-sections so distended, or have some detail so weak, that if tested to destruction, failure would occur

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* In illustration the following tests are cited:

A 4-in., wrought-iron, I-beam column, 6 ft. 6¼ in. long with rounded ends and a ratio of length to radius of gyration of 161, tested by Mr. Christie, at Pencoyd, had no appreciable deflection until the load almost reached 10 300 lb. per sq. in., at which point it deflected 0.03 in. It failed at 12 113 lb. per sq. in. Euler's formula for this ratio of length to radius of gyration and for a modulus of elasticity of 27 000 000 gives 10 300 lb. per sq. in. (*Transactions*, Am. Soc. C. E., Vol. XIII (1884), p. 111.)

The Watertown Arsenal Report for 1910, p. 172, describes a steel column, 13 ft. 8¾ in. long, composed of one web 10 by ⅜ in., and four angles, 4 by 3 by ⅜ in., tested with flat ends, which had no deflection up to and including 32 000 lb. per sq. in. At 34 000 lb. per sq. in., the deflection was 0.17 in. and at 34 710 lb. per sq. in., it failed by deflection. The ratio of length to radius of gyration was 100. The yield point, as shown by tests of three similar columns with a ratio of 12, was 36 000 for this grade of steel.

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TABLE 2.—Yield Point in Tension and Compression, and Failure in Compression.

All bars from the same blow of Bessemer steel.

All specimens of each size from the same bar, and all of full size, "as from the rolls," except the tension tests of 3-in. flats.

All compression specimens tested with flat ends.

The specimens used for determining the yield points in compression were two diameters long.

All results are given in pounds per square inch.

Compiled from tests made by the late Charles A. Marshall, M. Am. Soc. C. E., and given in *Transactions,* Am. Soc. C. E., Vol. XVII (1887), p. 68, Tables 1 and 2.

Shape of bar and diameter, in inches.	Yield Point.				Failure Loads in Compression. Ratios of Length to Radius of Gyration are Given in Columns Headed $\frac{l}{\rho}$.							
	Tension.		Compression.		1 Test each.		1 Test each.		1 Test each.		1 Test each	
	No. of tests averaged.	Load.	No. of tests averaged.	Load.	$\frac{l}{\rho}$	Load.	$\frac{l}{\rho}$	Load.	$\frac{l}{\rho}$	Load.	$\frac{l}{\rho}$	Load.
¾ Round.	4	46 090	1	47 300	50	44 980	..	......	..	......	..	......
1 "	4	44 202	2	46 020	48	44 000	..	......	..	......	..	......
1¼ "	3	40 747	2	43 460	48	40 850	..	......	..	......	..	......
1½ "	3	40 275	2	41 290	48	41 880	..	......	..	......	..	......
1¾ "	3	40 017	2	42 075	48	39 950	..	......	..	......	..	.....
2 "	3	38 207	2	38 830	48	40 850	..	......	..	......	..	......
2¼ "	1	37 000	2	38 125	48	36 790	72	36 580	..	......	..	......
2½ "	1	36 100	2	36 840	48	35 650	70	34 450	..	......	..	......
¾ Square.	3	44 273	2	43 845	45	44 960	..	......	..	......	..	......
8/10 "	2	47 815	2	49 055	..	......	..	......	..	......	..	......
1 "	3	43 560	1	44 025	42	43 080	..	......	..	......	..	......
1¼ "	3	41 060	2	42 300	42	40 060	..	......	..	......	..	......
1½ "	3	39 317	2	42 740	42	38 420	..	......	..	......	..	......
1¾ "	3	38 193	2	40 630	42	39 450	..	.....	..	......	..	......
2 "	No	test	1	39 870	42	39 750	..	......	..	......	..	......
2¼ "	1	38 310	2	39 940	42	39 270	63	37 330	..	......	..	......
3×⅜ Flat.	3	47 363	..	.....	42	47 650	63	46 420	83	46 150	..	......
3×½ "	3	44 417	..	......	42	41 650	..	......	83	43 490	104	42 170
3×¾ "	3	41 447	...	......	42	43 580	..	......	..	......	102	40 700
3×1 "	3	39 397	..	......	42	41 200	..	......	83	36 920	..	......
3×1¼ "	4	38 482	..	......	39	38 350	63	35 430	..	......	..	......
3×1½ "	4	37 820	..	......	42	36 920	..	......	..	......	..	......
3×1¾ "	4	35 917	..	......	42	35 760	..	......	..	......	..	......
3×2 "	4	39 302	..	......	42	37 670	..	......	..	......	..	......
4×½ " *	2	53 800	..	......	42	55 420	63	55 110	83	55 320	104	51 210
4×1 "	2	41 415	..	......	42	42 630	..	......	..	......	104	39 270
4×1¼ "	1	36 680	..	......	42	39 300	..	......	83	38 200	..	......
4×1½ "	1	37 580	..	......	42	39 500	63	39 850	..	......	104	39 100

* "Bar finished at very low heat."

Note that the failures by compression occurred at or below the yield point, that the yield point of each bar was about the same in tension and compression, and that it varied greatly in different sizes.

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TABLE 3.—COMPRESSION TESTS, AT WATERTOWN ARSENAL, OF ROLLED STEEL H-SECTIONS. NOMINAL SIZE, 6 BY 6 IN., 23.8 LB. PER FT., TESTED IN HORIZONTAL POSITION, WITH WEBS VERTICAL.

The "elastic limit" per square inch in tensile tests of four specimens from flange and two from web is given as follows: From flange, 28 500, 31 840, 29 500, 30 490; average, 30 107. From web, 32 590, 31 850; average, 32 245.

Compiled from Watertown Arsenal Reports for 1908 and 1909.

Ratio of length to least radius of gyration.	TESTED WITH FLAT ENDS.			TESTED WITH PIN ENDS. PINS VERTICAL, IN PLANE OF WEB, AND 3 IN. IN DIAMETER.		
	Yield point, in pounds per square inch.	Ultimate, in pounds per square inch.	Initial horizontal deflection.	Yield point, in pounds per square inch.	Ultimate, in pounds per square inch.	Initial horizontal deflection.
25	30 000	43 110	None given	31 000	45 000	None given.
25	30 000	40 710	" "	29 000	44 000	" "
25	30 000	44 750	" "	29 000	46 000	" "
50	No yield point before ultimate was reached.	28 980	" "	....	28 850	0.08, 0.11 in.
50		28 620	" "	29 000	33 350	Kinky + 0.04 in.
50		29 000	" "		30 780	0.04, 0.03 in.
75		29 000	" "	No yield point before ultimate was reached.	28 000	0.07, 0.4 in.
75		29 000	0.04 in.		28 000	0.20, 0.12 in.
75		28 630	0.04 in.		28 650	0.07, 0.00 in.
100		28 000	wavy		24 000	0.23, 0.18 in.
100		26 000	0.00 in.		26 000	0.15 in.
100		28 000	0.00 in.		27 000	0.07, 0.10 in.
125		27 000	0.08 in.		22 540	0.10 in.
125		26 000	0.10 in.		23 925	0.20, 0.15 in.
125		25 000	0.17 in.		25 000	0.05, 0.06 in.
150		24 670	0.03 in.		20 360	0.15 in.
150		23 000	0.00 in.		17 130	0.16 in.
150		23 000	0.17 in.		10 100	0.42 in.

Note the great importance of the yield point in limiting ultimate capacity.

from local bending (or, as the author aptly terms it, secondary flexure), or from the giving way of some detail, under a load not much, if any, greater than the yield point.

The yield points of wrought iron and steel are, beyond question, the critical stresses for wrought-iron and steel columns, and should be substituted for the crushing resistances given in Table 1 as "the strength to compression."

In this connection, it is useful to know that the yield point of steel (and probably of wrought iron) is practically the same, for metal of the same quality, in compression and tension. This is illustrated in Tables 2 and 4 (after allowing for the fact that the yield points in compression, in Table 2, were determined from very short specimens, which tends, whether the stress be compression or tension, to raise somewhat the yield point), and many other cases could be cited if necessary.

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TABLE 4.—COMPARATIVE TESTS IN TENSION AND COMPRESSION OF SPECIMENS, 1¼ IN. IN DIAMETER, FROM OPEN-HEARTH, STEEL BARS OF TEN GRADES.

Specimens turned to 1.0092 in. in diameter. Compression specimens 12 in. long, with ratio of length to radius of gyration of 48.
Compiled from Watertown Arsenal Reports for 1886 and 1887.
All loads in pounds per square inch.

Mark.	COMPOSITION.			TENSION.		COMPRESSION.	
	C., per cent.	Mn., per cent.	Si., per cent.	Ultimate.	Yield point.	Yield point.	Ultimate.
833	0.09	0.11	....	52 475	30 000	30 500	32 125
123	0.20	0.45	....	68 375	39 500	37 000	39 190
782	0.31	0.57	....	80 600	46 500	44 500	45 500
795	0.37	0.70	....	85 100	50 000	47 000	50 875
803	0.51	0.58	0.02	98 700	58 000	57 000	58 000
797	0.57	0.93	0.07	117 400	56 000	57 000	65 500
823	0.71	0.58	0.08	116 750	56 000	56 000	65 440
750	0.81	0.56	0.17	149 600	73 000	76 500	87 750
756	0.89	0.57	0.19	141 290	76 000	77 500	84 125
334	0.97	0.80	0.28	152 550	80 000	83 500	91 500

Note that the yield point in tension and compression is about the same for each grade, and that failure of compression specimens of the five lowest grades occurred near the yield point.

Digressing, somewhat, from the direct theme of this discussion: Some engineers, in discussing the question of local slenderness or weakness, have advocated the doctrine that columns should be designed so that they cannot fail from local slenderness or weakness, but will, if tested, develop the full strength of the column considered as a whole. This is entirely a matter of economy and convenience, and of having ample stiffness and sufficient strength to carry the load required with an ample margin of safety. If the column design is good in these respects, there is no reason whatever for changing to a less economical or convenient form of cross-section. The cross-section usually has to be designed with reference to connections, method of loading, and other practical considerations, and, when thus designed, is likely to have section and dimensions which, though amply strong and stiff, will not develop the strength of the column, as gauged by its length, radius of gyration, and cross-sectional area, unless sectional area not needed for any other purpose is added. The important consideration is that the strength of a column shall be gauged by its weakest feature.

Reverting to a direct discussion of the paper: The Rankine formula is not a satisfactory one for practical use. It cannot be made to agree well with the results of tests of wrought-iron and steel columns of moderate length, and, when the constants are adjusted to make the formula agree as well as may be with the results of tests of such columns, it gives results much too high for long columns. On the

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other hand, if, by suitable constants, the formula is made to give proper values for long columns, it gives results unnecessarily low for those of moderate length, and, with the same constants, may give results altogether too high for short columns, as is the case with the author's adaptation of the formula, as gauged by his own experiments. These facts are shown in Table 5, in which it is also shown that, when an allowance is made for slight unintentional eccentricity, to the extent recommended by A. Marston,* M. Am. Soc. C. E., the author's recent experiments confirm with remarkable closeness the theory of eccentrically loaded columns. The comparison is all the more striking and convincing from the fact that the experiments were made by an advocate, on theoretical grounds, of the Rankine formula, who is, presumably, free from any prejudice in favor of the theory which, with some variation in detail, is supported by the analyses of Messrs. Marston, Cain, Moncrieff, Johnson, Jonson, and others who have discussed the subject of columns before this Society.

Marston's equation for nominally centrally loaded columns, and the close approximations to Marston's equation which others have derived, are tedious to apply, but they can be closely approximated as to results by easily applied empirical formulas. The following empirical formulas agree well with the results of the author's experiments on solid mild-steel columns, ½ in. in diameter, except in the case of very short ones, which failed at loads above the yield point; (these loads were, doubtless, much higher than those which the columns could permanently sustain without undue deformation).

For ratios of length, l, to radius of gyration, ρ, of 100 or less,

$$p = 58\,000 - 3\left(\frac{l}{\rho}\right)^2 \dots\dots\dots\dots (a)$$

For ratios of length to radius of gyration of 100 or more,

$$p = \frac{300\,000\,000}{\left(\frac{l}{\rho}\right)^2 + 7\frac{l}{\rho}} \dots\dots\dots\dots (b)$$

p, being the load per square inch of cross-sectional area.

These equations are arranged for the sole purpose of formulating the author's experiments on solid mild-steel columns, ½ in. in diameter, and, as arranged, are presented without recommendation for any other purpose. When made entirely general for any grade of steel or wrought iron, they become

$$p = \text{yield point} - \text{constant}\left(\frac{l}{\rho}\right)^2 \dots\dots\dots\dots (c)$$

$$p = \frac{\pi^2 \times \text{modulus of elasticity}}{\left(\frac{l}{\rho}\right)^2 + x\left(\frac{l}{\rho}\right)} \dots\dots\dots\dots (d)$$

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* *Transactions*, Am. Soc. C. E., Vol. XXXIX (1898), pp. 108-113.

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TABLE 5.—COMPARISON OF LOADS CAUSING FAILURE OF SOLID MILD-STEEL ROUND-ENDED COLUMNS, $\frac{1}{2}$ IN. IN DIAMETER. TESTED BY W. E. LILLY; AS SCALED FROM FIG. 4, WITH RESISTANCE INDICATED BY THEORY, RANKINE'S FORMULA, AND EMPIRICAL FORMULAS, a AND b (Equations a and b).

All results are given in pounds per square inch.

	THEORY (MARSTON*).			RANKINE'S FORMULA		
Ratio of length, l, to radius of gyration, ρ.	$p = \frac{58\,000}{1 + \frac{e\,y}{\rho^2}\sec.\left(\frac{1}{2}\frac{l}{\rho}\sqrt{\frac{p}{E}}\right)}$ y = distance from axis to extreme fiber. e = unintentional eccentricity.		Results of W. E. Lilly's experiments; as scaled from Curve A of Fig. 4.	As given by W. E. Lilly. $p = \frac{80\,000}{1 + \frac{\left(\frac{l}{\rho}\right)^2}{\frac{\pi^2\,E}{80\,000}}}$	As arranged for moderate lengths. $p = \frac{62\,000}{1 + \frac{\left(\frac{l}{\rho}\right)^2}{10\,000}}$	Equation a $p = 58\,000 - 3\left(\frac{l}{\rho}\right)^2$ Equation b $p = \frac{300\,000\,000}{\left(\frac{l}{\rho}\right) + 7\,\frac{l}{\rho}}$
	$e = 0.0$	$e = 0.00375$ in.				
						a
20	58 000	54 400	61 500	72 200	59 600	56 800
40	58 000	53 200	53 500	55 800	53 400	53 200
45	58 000	52 600	52 000	51 700	51 600	51 900
60	58 000	49 400	49 500	40 500	45 600	47 200
70	58 000	45 300	46 000	34 400	41 600	43 300
80	46 200	39 300	41 500	29 300	37 800	40 800
90	36 500	33 000	34 500	25 300	34 300	33 700
100	29 600	27 600	28 000	21 600	31 000	28 000
						b
120	20 600	19 800	19 700	16 350	25 400	19 700
140	15 100	14 700	14 500	12 700	20 900	14 500
160	11 600	11 400	11 200	10 100	17 400	11 200
200	7 400	7 320	......	6 770	12 400	7 200
300	3 290	3 270	......	3 160	6 200	3 260
400	1 850	1 846	......	1 810	3 650	1 840

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*First published by A. Marston, M. Am. Soc. C. E., in *Transactions*, Am. Soc. C. E., Vol. XXXIX (1898), pp. 108-113, and since endorsed by many authorities. Marston used a value of 0.06 for $\frac{e\,y}{\rho^2}$ in comparing his formula with Tetmajer's tests of mild steel. This value applied to $\frac{1}{2}$-in. round bars gives $e = 0.00375$ in., as above.

Note that Rankine's formula cannot be made to agree with the "Experiments," while "Theory" agrees very closely when slight eccentricity is assumed.

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The range of application of Equation c, and the value of its constant, have to be chosen to suit the series of columns for which the formulas are arranged. The value of x has then to be found by first determining the value of p for the length of column at which the application of Equation c ends and Equation d begins.

Equation c is a parabola; a form which the late J. B. Johnson, M. Am. Soc. C. E., advocated for short columns and those of moderate length. He, however, made his parabolas always tangent to Euler's curve, and advocated Euler's formula for long columns. On this basis, the constant for columns with pivoted ends is always

$$\frac{(\text{yield point})^2}{4\,\pi^2 \times \text{modulus of elasticity}}.$$

The writer prefers to increase the constant and modify Euler's formula for long columns, as per Equation d, in order to make a greater reduction for length. For bridges and buildings, long columns are usually tabooed, but for some kinds of construction they are not objectionable.

Professor Johnson compared his column formula with the very careful tests made by M. Considère. The tests with which the formulas were compared were of columns consisting of rectangular steel bars with pivoted ends, adjusted so that there was no appreciable eccentricity. The bars were of six degrees of hardness, and the results when plotted agreed with the corresponding six parabolic curves of the formula to an extent that was truly remarkable.

To show that the strength of a column, unless it is very short, is no function of the ultimate strength of the material, either in tension or compression, M. Considère cold-rolled the medium-hard steel, No. 5, which had a yield point of 47 000 lb. per sq. in., until it had elongated 10% of its original length. This raised its yield point to 71 000 lb. per sq. in., while its ultimate tensile strength was raised only from 83 000 to 88 500 lb. per sq. in. The columns of this steel, No. 6, with the yield point of 71 000 lb. and an ultimate of 88 500 lb. per sq. in., were stronger (in the maximum case more than 10% stronger) than the columns of steel, No. 8, with a yield point of 64 000 lb. and an ultimate strength of 98 000 lb. per sq. in.

Professor Johnson also showed that his parabolic formula agrees well with other tests, notably Tetmajer's.* His (Johnson's) diagrams, comparing his parabolic formula with Tetmajer's tests, were reproduced by Mr. Marston,† with the locus of his (Marston's) formula for eccentrically-loaded columns added, in his discussion of Professor Cain's paper on the "Theory of the Ideal Column." They were again published, as given by Marston, in Professor Cain's discussion‡ of

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* The information regarding Professor Johnson's parabolic formula and M. Considère's tests is taken from Professor Johnson's "Materials of Construction," pp. 361–363, and "Modern Framed Structures," pp. 148–152.

† *Transactions*, Am. Soc. C. E., Vol. XXXIX (1898), pp. 108–113.

‡ *Transactions*, Am. Soc. C. E., Vol. LXI (1908), pp. 204–205.

Mr. Prichard. the paper on "Safe Stresses in Steel Columns," by J. R. Worcester, M. Am. Soc. C. E.

These diagrams are very interesting and instructive. They show a close resemblance between tests and theory when provision is made in theory for the inevitable initial deviation between the axis and the line of thrust; that a parabolic, empirical formula for short columns and those of moderate length is about as good and much simpler than the theoretical one; and that the averages of the tests agree well with the parabolic formula advocated by Professor Johnson; but they also show that a curve which gives more reduction for length accords better with the minimum results.

This was one of a number of facts which influenced the writer, in discussing Mr. Worcester's paper,* to advocate a formula which gives a greater reduction. The formula, the reasons for advocating it, the method of using it in cases of intentional eccentricity, the additional limitations suggested for short columns, and other practical and theoretical considerations were outlined in this discussion and need not be repeated here, but it is best to add a caution with regard to the yield point.

The yield point varies greatly, even in steel from the same melt, as shown in Table 3, and will cause great differences in the strength of columns of ordinary lengths. This is especially important in dealing with columns made of thick plates and large, thick angles, which are likely to have much lower yield points than thinner and smaller sizes of nominally the same grade of steel. It will not do, in such cases, to pin one's faith unreservedly to any formula, no matter how well it is supported by tests of solid bars, ½ in. in diameter, or other small shapes.

Such tests, however, are very useful in determining experimentally the laws of columns by systematically varying one condition while others remain constant. The author's tests are to be commended, in this regard. To plat columns differing greatly in yield point, eccentricity, end restraint, and local stiffness on the same diagram in a kind of hodge-podge, only leads to confusion and tends to discredit the valuable information which has been acquired by analytical and experimental investigation. The value of rational investigation, in which sound theory explains and supplements experiments and experiments put to the test and verify sound theory, should receive general recognition.

An important step in this direction will have been taken when it becomes generally recognized that Rankine's formula is based on a blunder caused by a plausible but fallacious assumption of analogy in deflection of beams and columns, that it has only the semblance of a "theoretic basis," and that it is not even a good empirical formula for wrought iron and steel.

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* *Transactions*, Am. Soc. C. E., Vol. LXI (1908), pp. 165-178.

Mr. Branne.

J. S. BRANNE, M. AM. SOC. C. E. (by letter).—The writer has read this paper with much interest, and has been especially attracted by the attempt to find the size of lace-bars to connect the component parts of the columns, in order that said parts may act truly as one piece in the distribution of loading, which produces, generally, both direct compressive stresses and bending stresses, as it may be; and that even wide columns, meaning those of a low ratio of $\frac{l}{r}$ have some side deflection due to compressive loading, speaking now of such deflection in an "ideal column."

That there is a natural irregularity and deviation from a straight line, due to lack of uniformity in the component parts, is well known to all engineers, this very thing making the theoretical determination of strength so hard to reconcile with the data as actually revealed by tests.

It seems to the writer that there are two kinds of compression members: the wide ones and the slender ones; the first failing by flow of metal, directly compressed, the second by flow and flexure stresses, which latter are induced by the sidewise deflection of the compression member. By failing is here meant "a perceptible set, showing unfitness for further loading, not actual destruction."

Experiments have shown that wide columns, when properly fabricated, fail when the nominal unit stress approaches or ranges around the elastic limit. The experiments made by Mr. James E. Howard* show test results on wide columns. Just where to draw the line between "wide" and "slender" columns is not so easy. The Progress Report of the Special Committee on Steel Columns and Struts† gives a series of diagrams of tests, which are condensed into one diagram, Fig. 23, showing the results of many tests. The curves are quite flat up to $\frac{l}{r} = 70$, after which they drop more sharply.

The cross-sections of the columns in Mr. Howard's tests were about 90 sq. in., and the ratio, $\frac{l}{r}$, was 26 for Column No. 1, and 47 for Columns Nos. 2 to 5. Columns Nos. 1 and 2 did not fail; but Nos. 3, 4, and 5 did fail, Nos. 3 and 4 in the pin-plates, and No. 5 in the body of the column. The manner of failure in No. 5 was that the webs buckled, resulting in a "sharp bend, or set"; Mr. Howard's Fig. 1, Plate XLII, shows a photograph of Column No. 5 after failure.

In none of these columns was the failure induced to any perceptible degree by flexure stresses, as such combined action of direct compression and bending would have caused failure somewhere below the elastic limit.

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* *Transactions*, Am. Soc. C. E., Vol. LXXIII, p. 429.

† *Transactions*, Am. Soc. C. E., Vol. LXVI, p. 401.

Mr. Branne.

It must be remembered here that the test pieces of the component parts showed quite a variation in tensile strength, which makes it impossible to refer to a certain magnitude as the elastic limit of the column, as a whole. Columns Nos. 3 and 4 failed at points where the punching of many holes (with much subsequent riveting) induced numerous and complex local stresses; No. 5 failed by the buckling of the web at a point 12 ft. 8 in. from the end, probably due to local weakness, for the test load gave a nominal average unit stress of 30 490 lb. per sq. in. In these columns the lace-bars could not have had much to do before the elastic limit of the column was reached, when locally weak spots put them into activity. It does not seem possible to calculate the lace-bars in wide columns which fail at unit stresses approaching or ranging around the elastic limit. If lacing is used in such columns, it should be quite heavy, in order to take care of local weaknesses; or, still better, lacing should be avoided, and one should use cover-plates or continuous diaphragms, forming part of the section of the column, so as not to waste material.

If heavy lacing is used, the tie-plates at the ends of the columns should be long and thin, rather than short and thick, to steady up the member as much as possible; and where the component parts are fairly wide, say 15 in. or more, diaphragms should be used at the ends, in addition to the plates, thus helping to equalize the stresses carried into the compression member. Similar precautions should be taken at intermediate points where loads are applied.

As to columns of the second kind, namely, the slender ones, all tests show that failure occurs much below the elastic limit, clearly indicating the presence of bending stresses in addition to the direct compressive stress. The bending will induce shear in the columns, producing compressive or tensile stresses in the lace-bars.

If the deflection be assumed to result from a uniform transverse loading, which assumption is not quite correct, it will be evident that the stresses in the lace-bars are greatest at the ends of a free-end column. If the column is not free to move at the ends, but stands between this type and the one with restrained ends, the shear is also greatest at the ends, necessarily, but it is evident that greater care should be taken in this latter type to tie the component parts together more securely at the ends than for free-end columns. If comparison be made, then, with uniformly-loaded beams, it will be noticed that in one with free ends the longitudinal stress caused by the maximum center bending moment, $+\frac{wl}{8}$, has to be transmitted from the compression side to the tension side in a length, $\frac{l}{2}$; in the one with restrained ends, the same amount has to be taken up (from $+\frac{wl}{24}$ at the center to $-\frac{wl}{12}$ at the ends), but this presupposes that the column is held rigidly at the ends, a bending moment, $-\frac{wl}{12}$, is already supposed to exist, and this should be taken care of by extra long tie-plates or diaphragms between the channels. Mr. Branne.

To proportion the lace-bars under the assumption of uniform transverse loading, a working formula has to be used, for example, American Bridge Company, medium steel, $17\,000 \div \frac{1}{11\,000}\left(\frac{l}{r}\right)^2$, or American Railway Maintenance of Way Association, $16\,000 - 70\frac{l}{r}$, and the reduction of fiber stress is assumed as the unit extreme fiber stress due to bending, whence the uniform load can be found.

On this basis of approximating the real conditions, which certainly are unknown, it will be found:

(1) When the column is slender, yet the section not great, the average specification covers the size of lattice-bars very well.
(2) When the column section becomes quite heavy, and, at the same time, due to space requirement of some kind, the component parts, generally channel-shaped, are placed closely together, making failure evident in the lace-bars, it will be found that the generally used lace-bars, as given in the specifications, are not strong enough, but must be increased, finally resulting, economically, in doing away with lacing and substituting cover-plates, or a continuous diaphragm, as noted before.

Finally, as regards the wide column, while the lace-bars can have nothing to do from a theoretical sidewise deflection, at the same time, one component part may be stressed more than the other, due to a faulty foundation or a small error in fabrication, causing an uneven unit stress, which produces stresses in the lacing. As long as the component parts are small, such unevenness can be cared for by the lacing taking up the longitudinal shear; but, when the component parts are very heavy, the lacing cannot make them act as one, for, being proportionally so much lighter than the component parts, they become overstrained and yield. Cover-plates or continuous diaphragms cannot, of course, overcome the faults of foundation or errors in fabrication, but have the strength to transmit unevenness of stress without becoming overstrained, thus making the column act as one homo-

Mr. Branne. geneous piece, reducing the unevenness of stress in the component parts.

The tests conducted by Arthur N. Talbot, M. Am. Soc. C. E., at the University of Illinois Engineering Experiment Station,* showed an irregular action of the lace-bars, some of the bars showing more stress near the center than at the ends. Further data bearing on these tests may be found in the many interesting notes in the same bulletin.

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* *Bulletin No. 44*, June 6th, 1910.

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A BRIEF DESCRIPTION OF A MODERN STREET RAILWAY TRACK CONSTRUCTION.

Discussion.*

By William J. Boucher, Assoc. M. Am. Soc. C. E.

William J. Boucher, Assoc. M. Am. Soc. C. E.—In 1907, the franchises of many, practically all, of the street railway lines in Chicago had expired, and, through neglect of maintenance, mismanagement, and difficulties in financial affairs, the tracks and equipment were in a miserable and dilapidated condition. By popular vote, new franchises were granted, and by the ordinances of February 11th, 1907, the city became a partner in the street railway business, receiving 55% of the net receipts, and the Board of Supervising Engineers was created. The duties of this Board, as the name indicates, consisted of complete supervision of all the work necessary (including purchase of materials) to place the roadbed, tracks, cars, car-houses, power-houses, and substations in first-class working condition. Mr. Boucher.

The track work was completely remodeled. The first design, known as Type 1 (Fig. 3) was very similar to that described by Mr. Polk. It consisted of steel beam ties, embedded in concrete, which was of greater thickness beneath the ties and rails than between them, where the original earth was left in mounds, undisturbed. The ties were originally placed 4 ft. from center to center. The concrete embedding the ties was brought up flush with the surface of the top flange, which was wider than the bottom flange. These ties are 4¼ in. high, 6 ft. 3 in. long, and weigh 14½ lb. per ft. The tie is used merely to hold the rails down and to line and gauge; it is not depended on to transmit the car load to the soil, that function being performed by the concrete immediately in contact with the rail. A special form of fastening was designed in order to permit the removal of the rail for renewals without disturbing the tie. After the rail was fastened in place on

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* Continued from November, 1912, *Proceedings*.

Mr. Boucher. the tie, mortar filling was placed over its flange and upward on each side of the web, and packed under the head of the rail. Tie-rods, with two nuts at each end, pass through the webs of the rails. These rods are 2 by $\frac{5}{16}$ in. in section, which permits paving, of granite or wood blocks, between the tracks, the rods being placed in the usual spaces between the blocks.

Type 2 was a modification of the preceding, and differed from it mainly in the substitution of 6 by 8-in. oak or yellow pine ties, 7 ft. long. Tie-plates are placed under the rails, and the latter are secured to the ties by screw-spikes.

Type 2-A was designed from Type 2, and in it the ties are of wood. They are 3 ft. from center to center, and the excavation has been changed to a uniform section, replacing the mounds of earth between the ties with concrete and permitting the rolling of the excavated trench before placing the concrete. This type is now standard for all new work in all parts of the city beyond the limits of the "Loop" section.

Type 3 (Fig. 3) is used in the business or "Loop" section, where car, vehicle, and pedestrian traffic is very heavy and congested, and where the necessary time cannot be given for concrete to set properly, and also for the reason that the streets in this section are likely to be torn up frequently for conduit, water pipe, or sewer work or subway construction. In this type the sub-grade is rolled and on it is placed $1\frac{1}{2}$- or 2-in. broken stone. This stone is well tamped, on it are laid wooden ties, 2 ft. from center to center, and the usual track structure is built.

For all types the straight track rail weighs 129 lb. per yd. It is a girder rail 9 in. high, with 6-in. bottom flange and $\frac{1}{2}$-in. web. Guard and curve rails are of similar dimensions, but weigh 145 lb. per yd. The chemical composition is as follows:

For the straight rail:

Carbon	0.50 to 0.60	per cent.
Sulphur, not to exceed	0.08	" "
Phosphorus, not to exceed	0.10	" "
Silicon, not to exceed	0.20	" "
Manganese	0.80 to 1.10	" "

For the guard-rail:

Carbon	0.45 to 0.50	per cent.
Phosphorous	0.10	" "
Sulphur, not to exceed	0.08	" "
Silicon, not to exceed	0.20	" "
Manganese	0.70 to 1.00	" "

Wood ties treated with preservatives have been used extensively in the newer types of tracks.

All joints on straight track are electrically welded. This work is done under contract by one of the rail-rolling companies with its own equipment mounted on special cars, which run on the new track, and current is obtained from the trolley wire. The ends of the rails are Mr. Boucher.

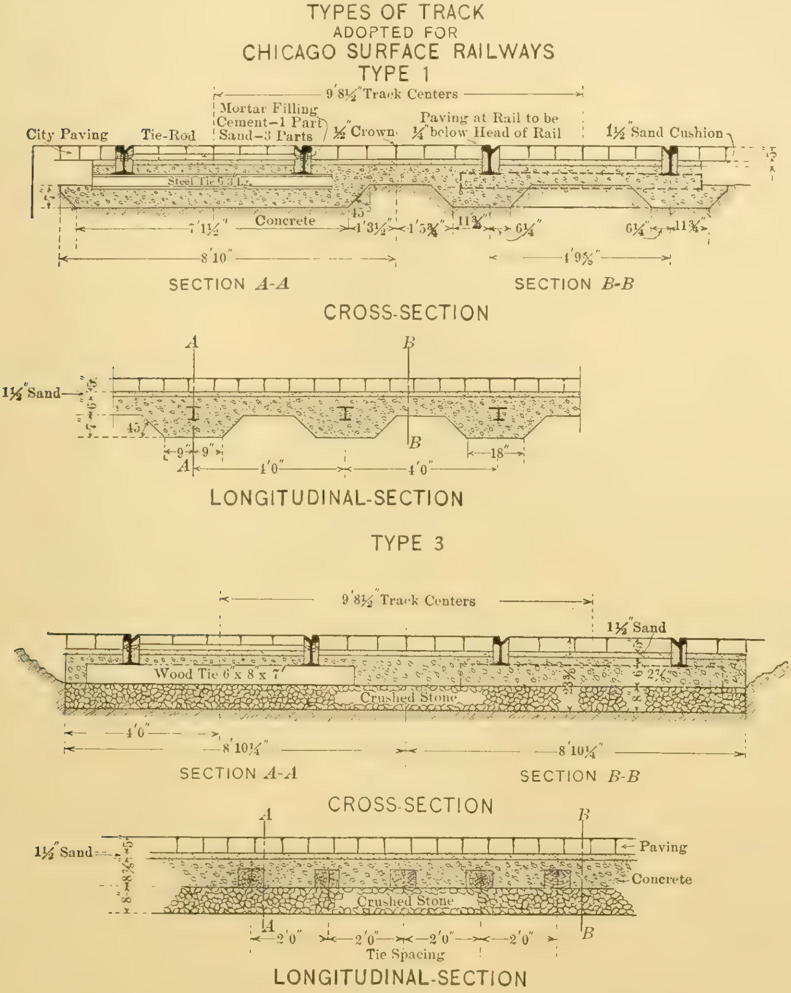

FIG. 3.

butted carefully, but not welded. The weld is accomplished by placing against each side of the webs of the abutting rails, a steel bar, about 1 by 3 by 7 in., on each end of which is a boss, about ⅛ in. high, the object of the latter being to insure good contact against the web. The

Mr. Boucher. bars are held rigidly against the web by heavy jaws operated by hydraulic pressure, and when thus held, a flux is applied and electric current of low voltage and exceedingly high amperage is turned on, the weld being completed in from 3 to 4 min. The heads of abutting rails are afterward smoothed down by a carborundum wheel. The conductivity of the joints must be equal to that of the rails joined.

This construction forms the smoothest running track the speaker has ever ridden over on any street surface railway.

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THE FLOOD OF MARCH 22D, 1912, AT PITTSBURGH, PA.

Discussion.*

By Messrs. Jean de Pulligny, J. Waldo Smith, and Morris Knowles.

Mr. de Pulligny.

Jean de Pulligny, M. Am. Soc. C. E.—The speaker knows very little about the Ohio River, as he only saw it once, but can say a few words about the very severe floods which have to be controlled in Paris, where they caused great damage three years ago. At the present time the speaker understands that the waters are rising again very rapidly, and the people are anxious to know whether they will have to undergo the same severe experience.

One of the solutions proposed has been the building of dams up stream. The Seine has several affluents, and the rising of the flood at Paris depends largely on the way in which the various rivers above send down their flow. If the floods arrive at Paris simultaneously, the rise there is very high; if they pass one after the other, the rise is much less, so that keeping one flood waiting a few hours and allowing it to escape afterward might be sufficient to prevent any great rise at Paris.

Besides the construction of reservoirs up stream, other measures have been proposed, and, generally speaking, all those which allow the water to flow freely between the city embankments and below the city may help, to a certain extent, to lower the crest of the flood.

It has been proposed to build, around the city, a deviation canal which would receive the flow of the Marne (an affluent of the Seine) above Paris, and carry it below the city. For helping the flow of waters below Paris, it has been proposed to construct an underground canal from Bougival to Poissy, which would cut straight across the several loops formed by the river below the city. All these works and many others would surely be useful, but, unfortunately, their cost would be very large.

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* Continued from November, 1912, *Proceedings*.

Mr. Smith. J. WALDO SMITH, M. AM. SOC. C. E.—The speaker is not familiar with the Ohio River, or with the circumstances or conditions which control the flow of the Allegheny in the Pittsburgh District, but if these streams are like those with which he is familiar in New York State, New England, and New Jersey, he is convinced that there has been no great flood, but that at some time there will be a greater one, and that there has occurred no great drought, but that at some time there will be a drier one.

To control these floods, and to utilize their waters by storage, is an extremely difficult problem. Floods in the rivers with which the speaker is familiar do not occur by rule; they are likely to occur in any month of the year. He has known of floods in July, in August, in September, in October, in January, March, April, May, and June, and, no doubt, a careful comparison of the records would show that floods had occurred in the other months of the year as well, and severe floods too. In order, then, to utilize the run-off waters for the development of an average power or for augmenting the low-season flow and, at the same time, furnish adequate protection against floods, is a difficult problem.

This discussion is a general one, for, as already stated, the speaker is not familiar with the problems of the Allegheny River, and it may be that floods in that region usually occur in certain seasons only.

Mr. Knowles. MORRIS KNOWLES, M. AM. SOC. C. E.—To the speaker and to others who have studied the conditions in Pittsburgh, this paper is exceedingly interesting. It will be recalled that some criticisms of the Flood Commission's Report have been based on the fact that it was founded on incomplete data regarding rainfall, run-off, and river gaugings; yet this paper is a study, using actual rainfall measurements and stream gaugings on every one of the streams on which the Flood Commission recommended reservoirs. The close correspondence of the results to those calculated on necessarily incomplete data for the Report proves the reasonableness of the Flood Commission's assumptions and justifies its belief that the seventeen recommended projects would prove effective in controlling floods.

Another interesting feature is the light thrown on the one flood which would not have been lower than the damage height, even with the seventeen reservoirs in operation, namely, the flood of 1907. The main causes at the time of that flood were the Kiskiminetas and the Youghiogheny, just as in the flood of 1912, although not exactly to the same degree. This study confirms the view that even these two offending streams could have been controlled (when we consider their time and intensity effect acting with all others) so that conditions would have been materially better.

A word as to the recurrence of floods, and as to the reasonableness of considering any project, not only for this purpose, but for other and corelated purposes: During the past 38 years, about 75% of the floods at Pittsburgh have occurred between December 1st and April 1st; the remaining 25% have been scattered through the other months, and, with one or two exceptions, have been small and of short duration. Of this 25% not one would have topped the flood wall which the Flood Commission recommended to supplement the seventeen reservoirs. The reservoirs, therefore, would have been necessary for flood protection only during 4 months of the year, and could have been operated for other purposes during the remaining 8 months. It was this which led the Pennsylvania Water Supply Commission to incorporate such restrictions as the following in two power company charters that have been granted since the Flood Commission made its report: Mr. Knowles.

"That the requirements of the Corps of Engineers, United States Army, in charge of the Allegheny River, as to the minimum stream discharge must be embodied in any plan for using the water stored, as well as the rights of lower riparian owners to have available at all times at least the minimum stream flow, as determined by the Water Supply Commission of Pennsylvania, must be protected.

"That the operation of reservoirs, in so far as the control of floods and the maintenance of low-water flow is concerned, shall be subject to the direction and jurisdiction of the Water Supply Commission of Pennsylvania."

There has been some discussion with regard to the effect on acid conditions. The speaker had hoped that the report of the Flood Commission had made it evident that in this matter, also, there was great benefit to be obtained by this plan. All but four of the proposed reservoirs are located on portions of streams which are not now acid. It is true that some others may become acid, but the location of the reservoirs, near the head-waters, and above most of the mine developments, will restrict this to a minimum. Moreover, the effect at the low-pool dams is no criterion whatever of what will happen in a very large basin with a comparatively high dam. There a sudden rise will not flush out the acid which has accumulated in the bottom, but will dilute it to a greater and greater degree until it overflows the spillway. The same great dilution will take place when a full reservoir is drawn down to prepare for another flood.

The speaker has not the exact figures in mind, but the increased stage at low water on the Allegheny River and the consequent dilution, made possible by the proper operation of the seventeen reservoirs, would result in a reduction of both the hardness and the acidity of that river of something like one-half or one-third at extreme stages, with a marked reduction at other times.

The idea of the beneficial use of such reservoirs for many purposes other than the prevention of floods has resulted, as Mr. Grant has remarked, in the organization of a group of interested people in

Mr. Knowles. Pennsylvania; some of these are capitalists seeking investment and some are public-spirited citizens and representatives of civic bodies, who have come together on the common ground of desiring a sane development of the water resources of the State. They believe that the doing of one thing does not necessarily antagonize the doing of another, and that many great benefits can be obtained through private development with State regulation and co-operation. They are, therefore, interesting themselves in developing the water laws of the State.

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STATE AND NATIONAL WATER LAWS, WITH DETAILED STATEMENT OF THE OREGON SYSTEM OF WATER TITLES.

Discussion.*

By Kenneth C. Grant, Assoc. M. Am. Soc. C. E.

Kenneth C. Grant, Assoc. M. Am. Soc. C. E.—The speaker is particularly interested in this valuable paper because of the direct applicability of the fundamental principles therein stated to the broad policy of water conservation which is now being advocated so strongly in Pennsylvania by the Flood Commission of Pittsburgh and the recently organized Water Utilization Association of Pennsylvania. Mr. Grant.

The Flood Commission was organized by the Chamber of Commerce of Pittsburgh, in 1908, to investigate the causes of, and damage by, the frequent disastrous floods at Pittsburgh, and to study and decide on methods of relief. After four years of exhaustive investigation, for which about $125 000 (obtained from county and city appropriations and by private subscriptions) was expended, the report of the Commission, published in April, 1912, recommended the construction of storage reservoirs on certain tributaries of the Allegheny and Monongahela Rivers. The flood relief which would be obtained by these reservoirs, naturally, would not be confined to Pittsburgh, but would extend to many other communities on the rivers above and below that city. Moreover, the proposed reservoirs would not only provide this flood relief, but would cause an increase in low-water flow which would add greatly to the usefulness of the streams for navigation, water supply, and power purposes.

The Commission pointed out, therefore, that the solution of the problem was so broad in its scope, and so far-reaching in its benefits, that it did not concern the City of Pittsburgh alone, but demanded

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* Continued from November, 1912, *Proceedings*.

Mr. Grant. State and National consideration and co-operation. The decisions to which these investigations have led have been aptly stated by the author when he says:

> "Some interstate legislation is absolutely essential if the highest development of our streams is to be accomplished. Each river, from its head-waters to its mouth, should be treated as a unit, regardless of State lines."

The Water Utilization Association of Pennsylvania was formed for the purpose of framing and obtaining legislation which should bring about the fullest development of the water resources of the State, and at the same time preserve and dedicate the benefits of such development to all the citizens of the Commonwealth.

This Association and the Flood Commission have given careful consideration to the same thought as that embodied in the author's statement:

> "Soon the State and Nation must join in the storage of water for the control of floods and to aid navigation. This water, in passing down the stream, will benefit many private power projects, and these should be compelled to contribute to the cost in proportion to the benefits received."

These bodies, in their work, have also in mind the natural converse of this statement, that private water-power companies, proposing to construct large storage works which will assist in providing flood relief and will improve the rivers for navigation, water supply, and water-power purposes, should receive corresponding co-operation and assistance from the State and National Governments. There are instances in Europe where private water-power companies have been assisted in the construction of their storage reservoirs by the Government in return for a certain amount of additional storage capacity to be constructed and kept empty for flood control. Private users of water for domestic or industrial supply, or for power, located below such large storage works, should also contribute to the cost of their construction in proportion to the benefits received. If effective legislation providing for such co-operation can be framed and enacted, it will ensure the fullest development of the water resources of the State.

Legislation tending toward this end has in fact already been passed in Pennsylvania. At the last session of the Legislature, a bill, drafted by the Flood Commission, was introduced and passed, enabling counties to borrow and expend moneys for the construction of works for flood relief, and also to enter into contracts with each other, or with the State, with other States, or with the United States, for the purpose of carrying out the necessary works.

It is hoped that legislation broadening the powers of the Water Supply Commission of Pennsylvania may be obtained at the coming

Mr. Grant.

session of the Legislature. This Commission, in operation since 1905, is charged with obtaining such complete knowledge of the water resources of the State as shall enable it to provide for their most equitable distribution. It has power over the granting of charters for water-supply and water-power companies, but has no authority where the water is taken by corporations for their own use, by private individuals, or by municipalities. Its effectiveness, in carrying out the purpose named in the act creating it, therefore, is considerably restricted. Its jurisdiction should be widened to cover all users of water.

Within the limits of its powers, the Water Supply Commission of Pennsylvania has done most admirable work, some of it along lines similar to that of the Board of Control described by the author; for example, the work of the Oregon Board for the protection of the public interest, of which the author says: "Public interest demands that water be put to the highest use. * * * an application for either irrigation or power can be denied if it is in conflict with the higher use for domestic supplies," is identical in principle with the attitude of the Pennsylvania Commission in considering applications for charters. There are instances in Pennsylvania where prior applications for charters for water-power companies have been refused on the ground that the stream involved was needed for domestic supply. There are also cases where applications for charters for water companies for domestic supply have been refused, because they interfered, perhaps purposely, and certainly needlessly, with proposed water-power projects.

Charters for water-power companies have also been approved, with certain conditions. For instance, the charters for a large water-power project in Western Pennsylvania were approved recently, on certain conditions, notable among which were the protection of the interests of navigation and of riparian owners below the dam by the maintenance of a suitable minimum stream flow, the presentation, within 12 months, of data showing the extent to which the proposed reservoirs can be used to ameliorate floods, and the placing of the operation of the reservoirs, in so far as the control of floods and the maintenance of low-water flow is concerned, under the direction and jurisdiction of the Water Supply Commission. Had a similar commission been in existence in West Virginia, the plans of a large water-power project, recently chartered and about to begin actual construction, might readily have been enlarged and modified, to the great advantage of both the water-power company and the general public.

A thorough knowledge of stream flow throughout the State is also being acquired by the Water Supply Commission, through the operation of a large number of gauging stations. A complete collection of all existing stream-flow data, some of the records extending back for many years, is now being compiled, and will shortly be published.

Mr. Grant. The Commission has also collected and filed complete statistics of all water and water-power companies in the State, including municipal water supplies. These data are also briefly shown on large-scale county maps of the State, which are convenient for reference in studying the relation of proposed to existing uses of water in a given region. It is evident, therefore, that in Pennsylvania, there is already in existence a body which, if given larger powers, can effectively protect the public interest and assure the most equitable distribution of the waters of the State.

Referring again to the treatment of a stream as a unit from its source to its mouth, there are several interesting and instructive examples of this broad policy in Europe, which the speaker has had the opportunity to examine on two occasions during the last few years.

The largest stream thus treated is the Ruhr River, which empties into the Rhine on the right bank at Ruhrort, in Western Germany. This stream has a length of 143 miles from source to mouth, and drains an area of 2 041 sq. miles. It flows through the great industrial region of Germany, around Essen and Mülheim, and is extensively used as a source of domestic and industrial supply and for power. The demands on the stream became so great that during low water the supply threatened to be inadequate. In 1897, after long deliberation and much difficulty, a voluntary association was formed by the users of the Ruhr water for the purpose of improving the flow of the river. The membership of this association includes cities, factories, water-power companies, etc. There are eleven dams on the tributaries of the Ruhr, ten of which were built by smaller associations of the water users on the respective tributaries, and one, now nearing completion, by the Ruhr association. These smaller associations were formed under a Prussian law. After two-thirds of the water users below the proposed dam have agreed to form such an association, the other third is obliged to join with them. The main association of the Ruhr, called the *Ruhrtalsperrenverein,* was formed voluntarily, without such a law; but it can compel users of water from the Ruhr to pay into the association, in the case of water-power plants, according to the head and the quantity of water used, and, where water is taken for domestic or industrial supply, according to the quantity used. The assessments on the members of the smaller associations on the tributaries are made in a similar manner. The main association of the Ruhr pays about $70 per annum per 1 000 000 cu. ft. of storage capacity of the reservoirs to each of the ten associations on the tributaries.

Another example of similar co-operation in river regulation is to be found on the Wupper River, the next tributary of any size emptying into the Rhine on the right bank above the Ruhr. It has a drainage area of about 240 sq. miles, and flows through the thickly

Mr. Grant.

populated manufacturing region around Barmen and Elberfeld. Before the construction of reservoirs on its tributaries, the stream had a very irregular discharge, varying between 0.05 and 90 sec-ft. per sq. mile of drainage area. Flood damage was frequent and considerable, and the numerous water-power plants suffered greatly from low water.

After long deliberation, an association for the construction of reservoirs in the drainage area of the Wupper was formed under a special Prussian act. This association has built three reservoirs on tributaries of the Wupper, for the control of floods and the increase of low-water flow. All water users below these dams must pay an annual assessment to the association.

A third association, of similar character, has constructed six reservoirs in the Görlitzer Neisse, near Reichenberg, in Bohemia. This stream rises in Northern Bohemia and flows northward for 124 miles, emptying into the Oder River about 15 miles below Crossen, in Prussia. Its valley receives a heavy precipitation in its upper portion (13.5 in. in 24 hours having been recorded at some points) and has been repeatedly devastated by floods; therefore, after the great flood of 1888, an association was formed to plan and carry out the construction of protection and regulation works, consisting of widening and straightening the channel and raising and protecting the banks. The estimated cost of these improvements was so heavy, and their probable effectiveness in a great flood so doubtful, however, that practically nothing was done by the association, the actual work confining itself to repairing damages and building the bank protections most urgently needed by the individual property owners.

In July, 1897, this part of Europe was visited again by devastating floods, which revived public interest in flood relief to such an extent that a convention, in which all the neighboring cities and towns were represented, was held in Reichenberg in the fall of that year. At this meeting it was decided to investigate the feasibility of constructing reservoirs for flood control. In January, 1901, the preliminary studies were sufficiently complete to establish the general plans, which contemplated the construction of six reservoirs in the neighborhood of Reichenberg, controlling the run-off from about 29 sq. miles, and in critical flood time holding back about 3 530 sec-ft. of damaging flood discharge.

The result of the investigations gained the association many new supporters, and assured the sympathy of the population of the entire valley of the Neisse with the project. In fact, one of the most noteworthy features of this undertaking is the widespread interest it aroused in the surrounding country and the universal financial support it received. Although all the reservoirs are located in Bohemia, the benefits, both in flood control and increase of low-water flow, are

Mr. Grant. felt by the Saxon and Prussian interests along its lower course, and these two countries, together with various cities, communities, and private interests, co-operated with Bohemia in their construction. The total cost of the work was $1 320 000, and the following contributions show the extent of the co-operation:

Bohemian Government	$660 000
Prussian Government	38 400
Prussian Province of Silesia	9 600
Prussian County of Ober-Lausitz	14 400
City of Görlitz (Prussia)	14 400
Saxon Government	24 000
Combination of Saxon and Prussian water interests	72 000

It is also of special interest that the users of water for power development from three of the reservoirs pay $12 per h.p., and from the other three reservoirs, $28 per h.p. per year. Three of the dams for these German reservoirs are shown on Plate CXXXIX.

As an instance of what such co-operation might accomplish in the United States, the conditions in the Beaver Valley in Western Pennsylvania may be mentioned. This stream drains about 3 040 sq. miles, and empties into the Ohio from the north about 25 miles below Pittsburgh. It is extensively used as a source of domestic and industrial supply, as it flows through a thickly-populated manufacturing district. It is also used considerably for power. On its upper waters there is an ideal reservoir site where a low earthen dam would create a reservoir of large capacity, overflowing a large tract of useless swamp land. This site has already been studied as the source of feed-water for the proposed Lake Erie and Ohio River Canal. It has also just been carefully surveyed and mapped by the State Water Supply Commission, under a special appropriation by the Legislature, for the purpose of determining the possibilities and best use of the site. Here is an ideal condition for a *Beavertalsperrenverein,* which could be made up of the water users in the Beaver Valley and the Canal Company, with the possible addition of the communities along French Creek, a large northern tributary of the Allegheny, because of the flood control that would be afforded by a second reservoir proposed by the Canal Company on the north branch of this creek, which would impound the flood-waters of that stream and deliver them through a canal into the reservoir on the Beaver River head-waters.

Another example of what might be done by such co-ordination of interests is afforded by the Youghiogheny River, a stream rising in Northern West Virginia, and entering the Monongahela 15 miles above Pittsburgh. This stream is used extensively as a source of industrial and domestic supply, and has several favorable sites for water-power

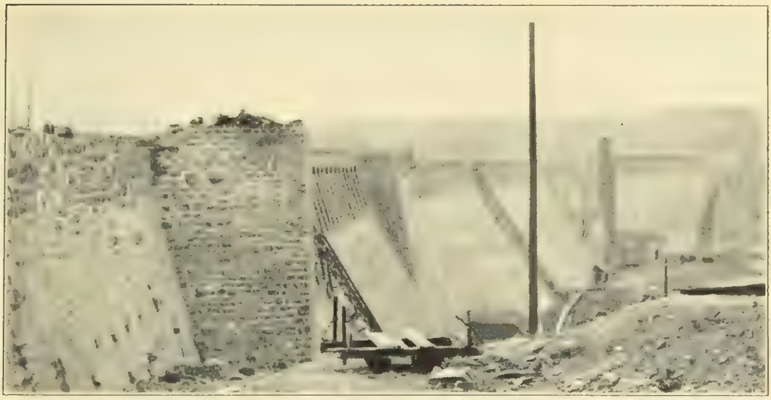

FIG. 1.—DAM BUILT BY ASSOCIATION FOR IMPROVING LOW-WATER FLOW OF RUHR RIVER, GERMANY.

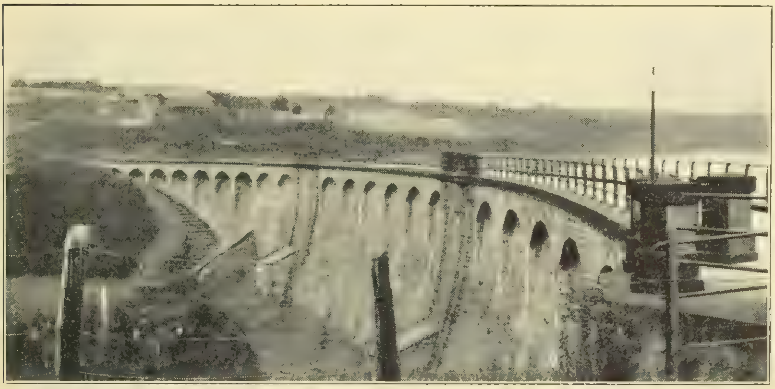

FIG. 2.—DAM BUILT BY ASSOCIATION FOR CONTROLLING FLOODS AND INCREASING LOW-WATER FLOW OF WUPPER RIVER, GERMANY.

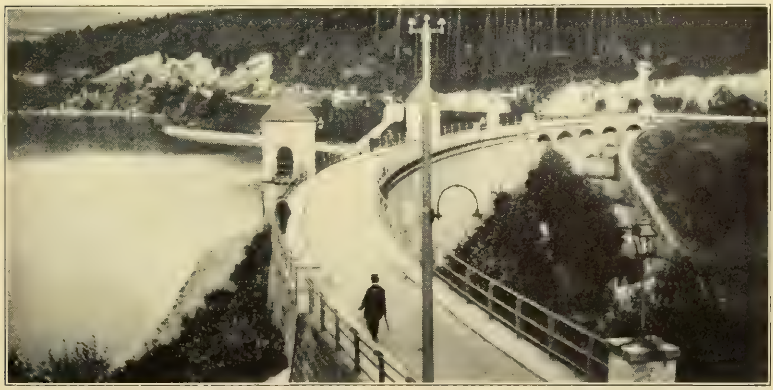

FIG. 3.—DAM BUILT BY ASSOCIATION FOR CONTROLLING FLOODS AND INCREASING LOW-WATER FLOW AT REICHENBERG, BOHEMIA.

Mr. Grant.

development. The Flood Commission of Pittsburgh proposes to store part of its flood run-off for the control of floods and for the improvement of the low-water flow, this stream being one of the chief offenders in Pittsburgh floods. The United States Government proposes to slack-water the lower 19 miles, to provide navigation up to West Newton, although a study of the low-water flow indicates that a pool-full stage could not be maintained without the assistance of additional water from storage reservoirs during dry weather. The co-operation of all these interests in the construction of storage reservoirs for the regulation of the flow of this river would unquestionably be of great benefit to all concerned. It would make feasible the development of a large quantity of water power which cannot be developed economically if the entire cost of the storage works must be borne by the water-power interests.

A third example may be found in Eastern Pennsylvania, where a large water-power project in operation on the lower Susquehanna River could greatly increase its capacity if the low-water flow were increased by storage reservoirs on the upper waters. The value of such increased flow to this one power plant would not pay for the cost of constructing such reservoirs; but if other plants, made feasible by the increased low-water flow, were constructed, and contributed to the cost of the storage works, and if co-operation were also obtained from the communities, counties, railroads, and other interests damaged by floods, such a broad treatment of the river would undoubtedly become feasible.

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THE SEWICKLEY CANTILEVER BRIDGE OVER THE OHIO RIVER.

Discussion.*

By Messrs. L. J. Le Conte, Charles Worthington, Theodore A. Straub, and C. W. Hudson.

Mr. Le Conte.

L. J. Le Conte, M. Am. Soc. C. E. (by letter).—There is apparently nothing whatever to show why the cantilever type was selected for this simple bridge site. As far as one can see by the plans, there are no local physical conditions which call for it. It seems to the writer that three simple spans, approximating 450 ft. each, would cover the ground and furnish a stiffer, far better, and cheaper structure in every respect. He ventures to say, moreover, that the probable saving in first cost would have been fully 25%, if not more; consequently, he naturally cannot see the propriety of building such a structure at such a site.

It is natural to presume, therefore, that the taxpayers of Sewickley Borough and Moon Township, who paid for it, have substantial grounds for complaint.

Mr. Worthington.

Charles Worthington, M. Am. Soc. C. E. (by letter).—The writer would like to inquire what provision was made in this bridge to take care of the secondary stresses which develop in a cantilever truss of this type?

In the old Quebec Bridge, these secondary stresses were of such magnitude as to destroy the structure when the direct or axial stresses were about one-half the elastic limit of the material.

In the Beaver Bridge,† a very expensive roller bearing was provided under the main pier supports to reduce the secondary stresses.

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* This discussion (of the paper of A. W. Buel, M. Am. Soc. C. E., published in September, 1912, *Proceedings*, and presented at the meeting of November 20th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

† "The Pittsburg and Lake Erie Cantilever Bridge over the Ohio River at Beaver, Pa.," by Albert R. Rayner, M. Am. Soc. C. E., *Transactions*, Am. Soc. C. E., Vol. LXXIII, p. 136.

Mr. Worthington. In the Sewickley Bridge the members seem to have been proportioned for the axial stresses only. The writer has investigated a few of the members shown on Plate LXXXII, and finds that the sections agree pretty closely with those required by the stresses given on that plate and the unit stresses given in the body of the paper.

Consider, for example, the bottom chord member, L_{10}-L_{11}. Its length, l, is 900 in., and its radius of gyration, r, is 9.22 in. The unit stresses, as determined by the author's text, are then as follows:

For live load, $12\,000 - 40 \times \frac{900}{9.22} = 10\,040$ lb.

For dead load, double this, or 20 080 lb.

For live load, dead load, and wind load combined,

$10\,040 \times \frac{20}{12} = 16\,750$ lb.

So that the required sectional area of the bottom chord member, L_{10}-L_{11}, is as follows:

Dead load.........	1 467 400	at 20 080	=	73.0 sq. in.
Live "	623 600	" 10 040	=	62.0 " "
				135.0 " "
Wind "	966 100			
Total	3 057 100	at 16 750	=	183.0 sq. in.

Taking the greater of these required areas, 183.0 sq. in., it will be seen that the actual area of 190.2 sq. in., is only 4% greater than that required, so that practically no excess of material has been added to take care of the secondary stress in this member, and the only provision for it lies in the unit stresses themselves. The writer does not think that 24 000 for dead load and 12 000 for live load, properly reduced for columns, are low figures for direct stress in steel of the character probably used in this structure.

The eccentric used at the L_0 point is in itself a source of secondary stress. If this eccentric were to be fixed in position so that the offset of centers of ½ in. lies in a horizontal direction—a very possible condition—there would be developed at this point a bending moment of $240\,000 \times \frac{1}{2} = 120\,000$ in-lb., which, measured in terms of the area of the two 10 by 1½-in. bars multiplied by the stress in the extreme fiber of bar, is $120\,000 \times \frac{6}{10} = 72\,000$ lb.

The axial stress in these two bars is constant at 384 000 lb., so that this secondary stress of 72 000 lb. amounts to some 18.7% of the axial stress. This secondary stress may not develop while the bridge is new, on account of the lubrication applied to the eccentric, but

Mr. Worthington.

it will certainly develop later. Taking the coefficient of friction between the pin and the bar at 0.4, the resisting moment to be overcome before the bar would rotate on the 9$\frac{3}{4}$-in. pin is, 384 000 × 0.4 × 4.87 = 750 000 in-lb., or about six times the amount necessary to develop the moment of 120 000 in-lb., due to eccentricity in application of the load to these bars.

Mr. Straub.

Theodore A. Straub, M. Am. Soc. C. E. (by letter).—The results obtained from the methods used in the construction of the Sewickley Bridge were so satisfactory that a few words from the writer may be of interest. In all the departments of the Fort Pitt Bridge Company —the drafting-room, shop, and erection—the results were economical in the broadest sense of the word. These methods also aided materially in establishing that complete confidence and hearty co-operation which is so desirable and effective in the execution of work of this kind among all persons connected with it.

Duplication of structural steel members cannot often be controlled, but it is frequently possible to duplicate the parts which compose such members, even if there is a marked difference in their final make-up. This may or may not be the duty of the purchaser's engineer, but, if it is, the latter, by the stand he takes in settling questions of detailed shop drawings, can often make a seemingly inexpensive piece of work very costly to the fabricator, or *vice versa.* It will be noted that a special effort was made to secure such duplications, and the consequent economical results were due to the latitude allowed to the Bridge Company by the County Engineer.

Where possible, all field connections were reamed in their final relative positions in the shop. This resulted in securing good fits and finish, and obviated the necessity of the correction of mistakes in the field. The writer might say, in passing, that this is the general practice of the Fort Pitt Bridge Works on all work of any magnitude, and it has always been felt that it is an economical method of procedure. All field connections were made in the manner planned, without trouble and interferences, the final connections and adjustments being especially satisfactory.

The writer believes that the special angle lacing bar, as described by Mr. Buel, was used for the first time, as such, in an important bridge member. In sufficient quantities its fabricating costs are not excessive, and the bars can be made in any blacksmith's shop which has a power hammer or press. This lattice bar is compact, efficient, and neat in appearance; it also has the additional advantage of readily shedding water.

Referring to Plate LXXXVII, entitled "Profiles for Erection": These data were used freely, and were found to be especially helpful throughout the erection of the structure. They proved a ready check

Mr. Straub. at all stages, and satisfied the engineers and erectors at all times that the work was progressing properly and safely.

The simple and inexpensive anchorage arrangement required the efforts of one man only in making the adjustment, thus giving extremely satisfactory results.

Both the wing and creeper travelers responded at all times to the duties planned and imposed on them in a very economical and efficient manner. It was also found that the adjustable features of the wing traveler, as well as the extra weight, did not affect the cost of its operation materially. The Bridge Company anticipates its use for future erection, and considers it a very good and efficient tool.

Complete harmony existed at all times among the engineers of the County and of the Bridge Company, and this was not the least of the pleasing results obtained by the methods used. All points in question were discussed freely and openly, and were settled promptly. Much credit is due to all in this regard and they deserve praise.

Mr. Hudson. C. W. HUDSON, M. AM. SOC. C. E.—It would be of interest to structural engineers to know how much it cost to make the anchor arms of this bridge self-supporting in case of a wash-out of the false-work. This expense, whatever it amounted to as a percentage of the whole cost, was in the nature of insurance against the loss of these arms, and against the loss due to the consequent delay in completing the structure in case of such wash-out.

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PORTS OF THE PACIFIC.

Discussion.*

By Messrs. L. J. Le Conte, E. P. Goodrich, and
Lewis M. Haupt.

L. J. Le Conte, M. Am. Soc. C. E. (by letter).—On page 1118[†] the author speaks in glowing terms of the future possibilities of the Lake Washington Ship Canal scheme, now well under way. As a matter of historical interest, it may be stated that, in October, 1871, the late Gen. B. S. Alexander, accompanied by Lieut. (now Col.) Thomas H. Handbury, M. Am. Soc. C. E. (both of the Corps of Engineers, U. S. A.), and the writer, as Assistant Engineer, went to Puget Sound with the view of making extensive "current observations" for the purpose of determining the practicability of harbor defense by torpedoes. While on this mission, Mr. Briar Brown and Dr. Whitworth, two estimable citizens of Seattle, took the party to the proposed ship canal site, and explained the scheme. Orders were received to make the survey, and called for plans, estimates of quantities, and probable cost of making a ship canal, Mr. Le Conte.

"with the view of ascertaining the adaptability of this lake for a naval depot, and the proper route for a ship canal to connect it with Admiralty Inlet, and the cost of such canal.[‡]"

The field work was done by Lieut. Handbury and the writer. The report of the results of this survey will not be found in the River and Harbor Index, because the expenses came out of "Surveys for Military Defense"; consequently, it will appear only among the Senate Executive Documents for the fiscal year ending June 30th, 1872.

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[*] This discussion (of the paper by H. M. Chittenden, M. Am. Soc. C. E., assisted by A. O. Powell, M. Am. Soc. C. E., published in September, 1912, *Proceedings*, and presented at the meeting of November 20th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

[†] *Proceedings*, Am. Soc. C. E., for September, 1912.

[‡] Report, Chief of Engineers, U. S. A., 1872, p. 26.

Mr. Le Conte. At the time this survey was made, it was claimed that the main object of the fresh-water depot was to enable the naval fleet to go up into Lake Washington, and, while taking on stores and supplies, all barnacles, sea-grasses, etc., befouling their bottoms would naturally drop off, leaving them clean when they proceeded to sea. In ordinary cases, of course, ships would have to go into dry dock to have their bottoms cleaned. For large vessels, this would be a matter of $2 000 per day in dock expenses, hence the great saving to be naturally expected. The writer has no doubt whatever of the great future possibilities of the Lake Washington Ship Canal, and will watch its growth in usefulness with interest.

Speaking of the Sound waters in general, the writer was greatly impressed by the bold shores everywhere. In fact, a 3 000-ton ship can go up to the shore, make fast to the trees, and lay there as long as necessary. This same feature was also noted in Lake Washington, and the writer is firmly of the opinion that it is due to vertical stratification; thus, whenever one stratum drops off, it always leaves a new vertical face standing. This natural feature makes trouble for the commercial wharves along the shore, but, nevertheless, it has its advantages in some cases.

The removal of Blossom Rock, in San Francisco Harbor, was a most interesting piece of work, and the fact that it ended disastrously was due, as usual, to unexpected contingencies. The writer had the pleasure of visiting the work several times during its progress, and just after the blast, in April, 1870, was told by the late Col. A. W. von Schmidt, the contractor, that he was compelled to set it off some time before he really intended, because of the exceedingly shaky condition of the rocky shell overhead, which had to be propped up with timbers. The tremor due to the working of the hoisting engine at the main shaft would start up leaks everywhere, and he was dreadfully afraid of a general collapse; hence the blast was premature. The subsequent quantity of dredging and scraping necessary to get the required depth of 24 ft. at low water ate up all the profits on the contract.

The draft of vessels entering the harbor gradually increased to 28 ft., and in November, 1902, a second contract was let for increasing the depth over the rock to 30 ft. at low water. The extra 6 ft. to be removed being largely loose broken stone, the contractor resorted to surface blasting, and excavating with a clam-shell dredge and a 10-ton bucket of the grapple type with long lever arms. The results were highly satisfactory.

The same system and dredge were also used in the removal of Shag Rock No. 2, and the results were equally satisfactory. The whole secret of success in surface blasts lies in the use of small charges, exclusively. The writer had local charge of the removal of Rincon Rock, in San Francisco Harbor, and the contractor engineer,

Mr. Le Conte.

Mr. Albert Boschke, made the great mistake of using 40-lb. charges for surface blasting before dredging the broken rock. Such large blasts simply expend their force in making a fine fountain, and the mechanical effect on the bottom, where it is needed, is practically nothing.

The quantity of powder required for each blast is that which will just begin to make a fountain. In most cases this is about 6 lb. of, say, 90% nitro-gelatine. These small blasts, judiciously distributed and followed immediately by clam-shell dredging, are by far the cheapest and most effective, where applicable.

A few remarks about the great jetty at the mouth of the Columbia River may not be out of place. The prodigious movement of sand mentioned in the early reports on this work proved to be a myth, and later experience showed that the sand simply traveled in an orbit of limited diameters. When the Point Adams Jetty was well extended, the sand movement practically disappeared, because it was "bottled-up." The depth of 31 ft. was obtained over the bar, and everybody rejoiced. Peacock Spit, on the north side, next to Cape Disappointment, was practically the natural north jetty. Unfortunately, Peacock Spit was cut away by subsequent heavy storms and strong currents, and as a result the bar shoaled up to its original depth of 21 ft. at low water. It is very evident that the only thing to do is to build another jetty from Cape Disappointment out along the crest of Peacock Spit, and thus maintain the spit and hold the tidal currents up to their work along and against the south jetty. The writer is of the opinion that a 31-ft. channel cannot be maintained unless Peacock Spit is fixed on the north side.

Dredging has grown to be a most important adjunct to every type of harbor work. The great advances made in machinery have cheapened the cost of dredging to such an extent that all schemes for proposed harbor work are now materially affected thereby. It may be stated that the day for extending jetties out into deep water in order to maintain the depth on the bar is gone forever The annual interest on the cost of deep-water extensions will pay for the necessary dredging five times over.

The improvement of tidal flats for commercial purposes is looming up everywhere. When the fact is considered that the new property, after full improvement, can be readily sold for $30 000 per acre, one can see how easy it is to pay for proposed schemes.

Everywhere in Europe it is customary for the government to condemn and purchase all property contiguous to a proposed harbor work, and, after improvements are completed, sell the property to the highest bidder. As a result, it not only gets all its money back, but in addition a handsome profit. The writer fails to see why the same cannot be done in the United States.

Mr. Le Conte. The work for bar dredges is growing more important every day. Where the entrance is largely under good shelter, the work can be done for 4 or 5 cents per cu. yd.; but where the bar is exposed to heavy deep-sea swells a large part of the time, the working period is cut down fully one-half, and the cost naturally goes up to 8 and 10 cents per cu. yd. These results are so flattering that harbors of any importance cannot afford to get along without a good bar dredge for general use, as it will pay back its first costs in one year's operation.

Mr. Goodrich. E. P. GOODRICH, M. AM. SOC. C. E.—Having been a student of port problems for some years, and being intimately connected with some of the work described in this paper, the speaker has studied it with considerable attention. Concerning several points, his interest has been specially aroused. The general problem of the Panama Canal and its effect on the commerce of the world is of great interest, and, together with the various physical problems discussed by the authors, has been of professional interest to the speaker. On these matters, however, he does not care to make any comments.

Concerning several non-professional points, the speaker's interest has been similarly aroused. Among these is the fact that, in a professional paper before the American Society of Civil Engineers, nothing but an obviously exaggerated newspaper report has been used in describing the port conditions at Los Angeles, Cal. The speaker may lay himself open to criticism for possessing unprofessional curiosity, but he must confess that had it been possible, he would have liked to await the authors' final discussion in order to ascertain whether or not they would correct the descriptions of the projected Los Angeles work, by making use of modified but obviously more accurate subsequent newspaper articles, to the files of which they evidently have access. The speaker is in entire accord with the opinion expressed in the paper, that it is possible that the popular enthusiasm which is now working such wonders on the Pacific slope may go too far, and that the pendulum may eventually start on a reverse swing. Thus, both in Portland, Ore., and in Los Angeles, Cal., he has laid himself open to the possibility of becoming unpopular by sounding a strong note of conservatism. It may not be out of place to state that the newspapers in both cities reported such fact, which might have been discovered by the authors had they read the local papers carefully. Because of the juxtaposition of the speaker's name, coupled with certain comments about the Los Angeles work, with the authors' reference to "shrewd promoters of port development and no less shrewd port engineering experts," who "will doubtless make the most of the present opportunity and ride on the crest of the flood wave to a point which the normal depth of water would not permit them to reach," he is afraid that casual readers will obtain an erroneous conception of the Los Angeles work and of his connection with it. Even the qualifications inserted by the authors are considered inadequate to meet the exactions of truth, and, therefore, the following facts are presented to the Society in an effort to secure justice for a city which the authors themselves have characterized as "incontestably the center of activity of Southern California" and destined to "become a great port, not because Nature made it so, but because her own virile people have said so." Mr. Goodrich.

The facts (which might have been ascertained by correspondence or by perusal of public prints) are as follows: The City of Los Angeles owns about 200 acres in the outer harbor, comprised in two tracts of about 150 and 50 acres, respectively. The outer harbor works now contemplate the immediate improvement of only one of these tracts, work on the 50-acre tract being practically under contract to the extent of bulkheading and filling, while plans for the 150-acre tract are in process of evolution, the detailed design being made subject to the determination of certain physical conditions with regard to currents, the occurrence of rock in the foundations, and the securing of certain real estate to provide rights of way for means of access.

In a professional paper* published nearly a year ago by Amos A. Fries, M. Am. Soc. C. E., Captain, Corps of Engineers, U. S. A., a suggestion was made with regard to the possibility of further improvement of the outer harbor, proposing a tremendous breakwater and certain long piers similar to those described by the authors and ascribed to the speaker:

> "* * * due to the fact that the ocean bottom becomes flatter as you go east from Point Fermin, the breakwater can be extended to inclose any amount of anchorage that may be desired. Indeed, a 25 000-foot extension, should that much ever be required, could be made on almost the same line as the outer arm of the present breakwater, and while keeping in depths averaging barely 48 feet would inclose 10 square miles of water, half of which would average more than 36 feet.
>
> * * * * * *
>
> "Not only can the breakwater be greatly extended, but if fifty or one hundred years hence a long extension becomes necessary, the harbor frontage itself can be increased at least 17 miles by the construction of nine slips between Deadmans Island and the entrance to the Long Beach Harbor. The slips beginning at the present 18-foot curve could be made in lengths varying from 6 500 to 2 100 feet, with a tongue of land 1 000 feet in width between each two slips.
>
> "It would seem advisable, whenever any considerable extension of a breakwater is made, to leave a gap 2 000 feet in width between the present breakwater and the beginning of the extension."

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* "Los Angeles Harbor," *Professional Memoirs*, Corps of Engineers, U. S. A., and Engineer Department at Large, Vol. IV, No. 13 (Jan.-Feb., 1912), p. 1.

Mr. Goodrich.

While the authors state that great reliance is being placed on the inner harbor in the development of port facilities, they also say that:

> "A great saving fact in the enormous labor of building the Harbor of Los Angeles is its close relation to the industrial development of the city. The lands into which the waterways are being dredged are admirably adapted for factory locations, and the material of excavation is being used in making the necessary fills. The whole development goes hand in hand in a way to produce the best results."

It is the speaker's firm opinion that the inner harbor will be developed almost exclusively for industrial plants and the outer harbor for deep-sea tonnage. At the wharves of the inner harbor, vessels with full cargoes for special manufacturing plants will berth. In order to make the best use of certain dredging which has already been completed, the speaker recommended, and it is understood that the contracts have now been let for, certain temporary wharves located on one of the arms of the inner harbor as now laid out. Only a portion of this wharf will be shedded, and this whole improvement will be carefully studied in an effort to determine what is likely to be the future of that portion of the port. It is further believed that the authors should have put their qualification with regard to the profitableness of reclaiming tide flats, noted under the head of "Dredging," in closer proximity to the point they endeavor to make of the great cost of doing the harbor work in Los Angeles. They say:

> "Now that the reclamation of tide flats is becoming so profitable an enterprise, dredging will be resorted to more than ever, the operation serving the double purpose of excavating slips and channels and filling the abutting lands."

Increased real estate values will be much greater in Los Angeles in comparison than in many other locations, so that moneys expended will produce larger returns for self-supporting enterprises, such as harbor propositions have generally shown themselves to be, and the criticism of the costly nature of the work at Los Angeles Harbor submitted by the authors becomes largely nullified. In reference to this, it may be well to call further attention to what the authors say with regard to San Francisco Bay:

> "The shoaling of San Francisco Bay is one of those great natural blessings which the unthinking are so accustomed to look on as a curse. One-tenth of its natural area, with deep connecting channels, would serve every possible need of commerce, while the other nine-tenths would be of immeasurably greater benefit reclaimed and turned to industrial or agricultural use. Every cubic yard of earth washed down from the rugged slopes of the mountains is worth a thousand times more in those low areas, where it is turned to efficient use in the service of Man."

As to the inner harbor at Los Angeles, the speaker has recommended certain alterations in the harbor lines, a portion of which proposed changes has been presented to the War Department for consideration, and it is hoped will receive its approval. Again, with regard to the inner harbor, such changes in harbor lines are in close accord with the recommendations contained in the paper by Capt. Fries, who writes as follows: Mr. Goodrich.

"Between Deadmans Island and the turning basin in the inner harbor there are 18 000 feet of bulkhead lines and 500 acres of land, most of which is now reclaimed. The frontage there may be increased a few thousand feet by slips. Above the turning basin, in the east and west basins combined, there are 750 acres of reclaimed land and 52 000 feet of frontage exclusive of the Salt Lake Railroad Company's land on the south and east. This frontage may be increased economically by slips to the extent of 13 000 feet.

"The above is along present approved harbor lines, and while the total—including the slips suggested by the writer and the 12 000 feet along the Salt Lake Railroad Company's property—amounts to 132 000 feet, or 25 miles, it does not represent half the frontage that can be developed if the future shall show that more is needed.

"Bounded by the bluffs of San Pedro on the west, the Anaheim Road and the city of Wilmington on the north, the City of Long Beach on the east, and San Pedro Bay on the south, there are some 8 square miles (about 5 000 acres) of swamp, tide, and submerged lands capable of being practically improved as part of the inner harbor. Before this is all developed it is evident that the present anchorage area will be too small.

* * * * * *

"* * * the land owned by the Salt Lake Railroad Company between the Long Beach Harbor and the east basin can probably best be developed by slips opening into the east basin and the Cerritos Channel between it and the Long Beach Harbor, giving a frontage of 12½ miles. On Plate V the channels are shown 500 feet wide on the north side of Cerritos Channel, where they are about 1 mile in length, and 300 feet wide on the south side where the lengths are 2 000 feet."

The authors are entirely wrong with regard to their criticism of the possibilities of the inner harbor of Los Angeles becoming silted by material carried in the floods of the Los Angeles and San Gabriel Rivers. The speaker cannot do better than quote again from the report of Capt. Fries:

"The question of maintenance of depths is always a very important one when considering the future of a harbor. In this matter Los Angeles Harbor is exceedingly fortunate. Indeed, it is hard to conceive of an ocean harbor that will cost less to maintain. The two causes of the deterioration of a harbor are silt carried down by rivers flowing into the harbor and sand piled up at the entrance by cross-currents and wave action.

"Ordinarily, the Los Angeles River is the only one whose waters reach the harbor during the rainy season. During the greater part of the year the river goes entirely dry before reaching the sea, due

Mr. Goodrich. to irrigation and the great quantities of water used in the city of Los Angeles. It is noted, however, that during the winter of 1910-1911 the San Gabriel River, which ordinarily flows into Alamitos Bay, about 10 miles east of Los Angeles Harbor, broke from its regular channel into one known as New River at a point about 20 miles from the harbor and, following the New River, united with the Los Angeles River at a point about 5 miles north of the harbor. This was one of the worst floods known in many years and carried into the Los Angeles Harbor possibly 350 000 cubic yards of material. Efforts are now being made by railroad companies and agricultural interests in the vicinity of the break to make such improvements in the bank of the river as will confine it in the future to its regular channel, emptying into Alamitos Bay.

"The Government has been asked to aid in this as a measure of protection to the harbor, and steps are being taken in that direction. Unquestionably this improvement will be made, but even if the San Gabriel River should regularly flow into the Los Angeles Harbor, the cost for dredging would still be comparatively small, as the records for nearly fifty years show only five serious floods. These occurred in 1867, 1873, 1884, 1891, and 1911. The Los Angeles River itself carries down some material in smaller floods at lesser intervals, but the amount is so small as to be scarcely noticeable, except just where the river first enters the deep water of the harbor."

Another point described by Capt. Fries, and now being actively pushed by the local authorities, is the widening of the channel between the inner and outer harbors to a minimum of 750 ft. A request for this improvement has been formally filed with the War Department, and it is believed that the Washington authorities look favorably on the suggestion.

In discussing the administrative systems of the ports, the authors criticize the conditions in Los Angeles, where there was originally and is now technically a divided responsibility. The trouble described by them, however, has been entirely overcome by the Mayor, who appointed what is called an "Advisory Harbor Commission," consisting of the two boards meeting jointly, with the Mayor as Chairman. During the meetings of this joint board all matters relating to harbor affairs are talked out, and differences of opinion are eliminated. The Mayor's solution of the small difficulty described by the authors has proven highly advantageous to the community.

With reference to the table of comparative costs to ship and to cargo in Pacific Coast ports, the fact should be pointed out that, with the exception of San Francisco, the table shows Los Angeles to have the lowest total cost. It should be noted further that the handling rate of 41.8 cents has been taken from an average which might be vastly different in an actual case. The dropping of the 0.8 cent would reduce the cost by nearly $200.

The speaker is extremely sorry that the authors were not more accurate in their statements with regard to Los Angeles Harbor, and believes that it throws grave doubt on the accuracy of the paper in other points. Mr. Goodrich.

Mr. Haupt. LEWIS M. HAUPT, M. AM. SOC. C. E. (by letter).—This is a very comprehensive paper, not only on the engineering problems of Pacific Coast harbors, but also on their commercial relations; and, in view of interesting discussions previously published in the *Transactions* of this Society,* the present contribution is one of great value to the Profession as a guide to and aid in the early solution of these intricate questions.

History and experience are the foundations of theory on which the engineer must rely to shape his course in order that he may best serve his Profession and his country by removing these obstacles to international commerce, hence it is that this paper is peculiarly appropriate on the eve of the completion of the Panama Canal. As it covers all the important ports from San Diego to Vancouver, no detailed discussion is possible, nor are the maps appended sufficient for such purpose; the text, however, supplements them in large part by stating local conditions and results, and several extracts therefrom are submitted as pointing to such modifications of practice and policy as to give promise of much greater certainty of securing early results.

As it is not possible to review all the cases cited, that of the typical and important Columbia Bar is taken as an example, because, as the authors very justly state:

"This work * * * is probably the largest and most difficult of its kind ever attempted * * *. The two great obstacles to be overcome are the storms and the teredo * * *. The roughness of the sea precludes the use of barges for dumping rock, thus necessitating a trestle, and the trestle piling is the particular delight of the teredo which puts it out of commission in from 10 to 20 months. * * * the embankment is progressively shaken down during each winter season."

Specifically, the work is described as follows:

"The jetty was to be built of large size stone on a brush mattress and raised to the level of low tide. Later, the project was changed to raise it to high tide, and four groins were to be built from the north side to arrest scour. Work was begun in 1885 * * *, and was completed ten years later at half the estimate. The depth on the bar had increased, in the meanwhile, from 21 to 31 ft., and the work seemed to have accomplished its purpose perfectly.

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* "On the Straits of Juan de Fuca, Puget Sound; and Government Improvements on the Pacific Coast," by B. W. De Courcy, M. Am. Soc. C. E., Vol. XXV, p. 420.

"Improving the Entrance to a Bar Harbor by a Single Jetty," by T. W. Symons, M. Am. Soc. C. E., Vol. XXXVI, p. 109.

"Description of Coos Bay, Oregon, and the Improvement of Its Entrance by the Government," by William W. Harts, M. Am. Soc. C. E., Vol. XLVI, p. 482.

"Seacoast Harbors in the United States," by C. E. Gillette, M. Am. Soc. C. E., Vol. LIV, Part A, pp. 297, 385.

"Notes on the Bar Harbors at the Entrances to Coos Bay and Umpqua and Siuslaw Rivers, Oregon," by Morton L. Tower, M. Am. Soc. C. E., Vol. LXXI, p. 349.

Mr. Haupt. "Several years later there was only the original depth of 21 ft. * * *. A new project was adopted extending the jetty 3 miles farther, * * * to be supplemented by dredging out the bar. * * * a permanent depth, of 30 ft. is sought.

"The jetty itself, as now being built, consists of a bed course of small rock as a substitute for the brush mattress, it being found impracticable to use the mattress beyond the shoal depth, * * * and the whole is covered on the seaward slope with very heavy rock ranging in weight from 6 to 16 tons per piece."

These extracts indicate that the usual resources of jetties built out from the shore by the aid of trestles and laid on mattresses, supplemented by dredging, are at least very unsatisfactory, if not impractical, at this locality, because of the activity of the teredo and the waves, so that the method has been modified to conform more closely to that proposed in the recent paper* by H. C. Ripley, M. Am. Soc. C. E.

Notwithstanding the great skill and ingenuity expended in the construction and maintenance of this trestle, more than 6 miles in length, and the excellent system of operation, the physical conditions are such as to retard its advance to such an extent that it seems impossible to overtake the deposits of littoral drift which constitute the bar; for the last official report available at this writing, states the following facts: The estimated cost to secure a depth of 40 ft. was $3 715 000. This project was revised to raise the jetty to mid-tide level, in 1909, at a cost of $3 529 300 and to make it 25 ft. wide at that level. In some places it is in 39-ft. depths, thus requiring an enormous increase in the amount of rock. Between September 20th, 1910, and June 30th, 1911, the dredge worked on the bar 62 days, removing 212 080 cu. yd. The project is 85% completed.

"The survey of June shows the channel to have shifted about 2 500 ft. to the northwest, and the depths vary from 25 to 27½ ft., an increase of 1 ft. over last year.

"The life of the trestle is very uncertain. * * * It is believed that the contraction of the entrance by the north jetty may be followed by scouring along the north side of the south jetty (2 miles distant), and that for its maintenance two more groins should be provided, each about 500 ft. long. The total appropriations since 1902 aggregate $7 901 852.25. The outer 24-ft. contour has advanced some 3 000 ft. since 1902, and the outer depths of 50 ft. in that year had shoaled to 24 ft. by 1909. On the southerly side of the jetty the 24-ft. curve had advanced about 4 000 ft. within 2 years, or about twice the length of the jetty extension in the same time, and large deposits had been made in the throat of the entrance between the jetty and Peacock Spit."

The deductions from these statements are that the extension of the jetty has caused deep erosion at its outer end, requiring enormous

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* "How to Build a Stone Jetty on a Sand Bottom in the Open Sea," *Transactions*, Am. Soc. C. E., Vol. LXXV, p. 1040.

Mr. Haupt.

quantities of rock to fill voids formerly occupied by sand in place; the rapid advance of the outer slope, accompanied by a shoaling of 26 ft. at the 4-fathom contour; the inability to overtake this advance by the jetty; the shifting of the channel some ½ mile to the northwest by the deposits of drift; the great excess of cost, amounting to more than $1 000 000 per ft. of depth gained; and the proposal to erect the second jetty extending out from Cape Disappointment for a distance of 2 miles, and at this same distance from the present jetty, but neither of them reaching to the crest of the bar by nearly a mile. The result of this must be to aggravate the seaward movement of the bar, while affording little or no protection for dredging.

It is also apparent that the report of 85% completion does not apply to the north jetty, nor to the ultimate extension of both, if this method is to be the main reliance for the improvement of this bar. The purpose of the south jetty, slightly convex to the channel, 4¼ miles in length, was to extend the protecting spit to a point abreast of Cape Disappointment and thus secure the co-operation of that headland, as a second jetty. This has resulted in disappointment, and any extensions of two jetties, it would seem, would give no promise of any different result, because there is no change in the general regimen of the entrance, affecting the relative equilibrium of the flood and ebb currents.

If the life of the piling, due to the teredo, is taken at the maximum limit of 20 months, then the entire structure subject to their attacks, must be rebuilt in that brief time, necessitating constant repairs and heavy expenses for maintenance. Moreover, the statement from actual experience that the dredge was able to work 62 days out of 283, or 22% of the time, covering the winter season, would give a reasonable assurance that it may be quite possible to work on the bar by creating an insular barrier on its outer slope, as a nucleus, sufficient to serve as a breakwater to protect a floating plant. From this a rock jetty could be extended shoreward to connect the deep-water areas on its outer and inner slopes, and to protect the crest from the littoral drift, as well as create a reaction from the impingement of the ample discharge on its concave face which would cut a channel more than 40 ft. deep automatically, as is shown by the existing channel at the base of the Point Ellice headland just within the throat of the entrance, which channel is about 8 miles long and more than 40 ft. deep, having a radius of 5 miles.

So confident is the writer that such a permanent, navigable channel could be readily obtained that, on June 9th, 1902, at the instance of the Senator from Oregon, he filed with the Secretary of War a proposal to guarantee such a channel for the sum of $2 500 000, which proposal was referred to a Special Board of Engineers for consideration and report. On October 14th, the Board gave a hearing to the

Mr. Haupt. officials of the Reaction Jetty Company (organized with a capital of $1 000 000 to execute the work), at which time a full discussion was submitted to the Board, all the members being present. On November 10th, 1902, the Board requested further information, and submitted twenty-three queries which were categorically answered on the 17th, and after several months of consideration, the report was filed with the Secretary of War, but its contents were not disclosed, and the Reaction Jetty Company was advised that it could ascertain the findings when the annual report of the Chief of Engineers was published. As that report has expunged all reference to the special provisions of the tender then submitted, and as 10 years have elapsed since it was made, and the recommendations of the Board, which were estimated to cost $2 260 000 for the extensions of the south jetty, at mid-tide level, a distance of 2½ miles, have been executed and for which appropriations approximating $8 000 000 have been set aside, it would seem appropriate that the terms of that proposal should be reviewed, as a matter of interest to the parties concerned, merely as an index to the early solution of this difficult but important problem of securing an open channel of ample capacity at reasonable cost without bar advance.

The principles involved have been tested on a practical scale at a condemned inlet on the Texas Coast, and notwithstanding the most serious physical as well as "metaphysical" obstacles, a detached jetty actually secured the full predicted depth of 20 ft. before the work was connected with the shores. Then it was seriously impaired, and the channel shoaled to 9 ft., requiring several years before equilibrium was restored. Thus assurance becomes doubly sure.

Briefly, the reaction jetty proposal reviewed the physical condition of the bar and its changes, as shown from official charts, stating that to obtain the 40-ft. channel would require the removal of some 30 000 000 cu. yd. which would be impracticable by dredging in the open sea with no protection works, as it would require some 30 years, if there were no littoral drift, to maintain the supply, and would cost more than $6 000 000.

To control this drift and create an automatic channel, the company designed a permanent structure to create a zone of local activity across the bar, to arrest the drift on its convex face, being on the windward or "weather" side of the proposed crossing, and, at the same time, to cause a continuous reaction, with erosion and deepening on its concave face, by utilizing the forces and agencies of impact, head, reaction, concentration, gravity, and continuous deflection, whereby a sufficient amount of the potential energy of the affluent water is developed locally to produce deep scour and lateral transportation.

The old jetty, completed in 1895, which created the temporary

30-ft. depth, had caused the bar to shoal up at the rate of 3 500 000 cu. yd. per annum, and pushed it seaward about 1 mile, reducing depths of 60 ft. to 30 ft., and less. Mr. Haupt.

To avoid this advance, the company proposed to make its work discontinuous, leaving a gap of about 2 miles between the outer end of the existing jetty and the inner end of the breakwater. The company also proposed to reverse the direction of the curvature of the breakwater, so as to place its cutting face toward the ebb currents and to receive them at first tangentially and, by gradual but continuous deflections, cause a constantly increasing pressure on the most vital part of the ebb for a distance of about 2 miles across the bar. Thus, too, the ingress of the flood tide would not be impaired, and the conditions of equilibrium would be changed in favor of the ebb stream.

Numerous other advantages, not incidental to straight jetties, were pointed out, time and expense were to be saved, and no risk was to be incurred by the Government, which was to be fully safeguarded by bonds, and pay only for work in place and depths secured.

Plans and cross-sections of the existing and proposed channels were submitted, with the form and dimensions of the proposed structure, closing with these words:

> "As the proposed plan is novel and the location one of exceptional difficulty, this Company desires, if permitted, to accept all the responsibility for the success or failure of its plan, and will furnish such security as the Secretary of War may require to protect the United States from loss by reason of its failure. It will also satisfy the Secretary of its ability to carry out the contract to execute these plans as rapidly as the physical conditions will permit * * *. We believe that this proposition will be found to be 'the most economical and advantageous to the Government,'* since it is based upon the utilization of a part of the enormous energy now going to waste over the bar."

After summing up the special advantage to be secured by the acceptance of the proposal, the Company pledged its good faith for its execution in the following words:

> "If this Board, therefore, can see its way to recommend to the War Department the acceptance of this proposition for the relief of the Columbia River Basin, it is believed that it will perform a public service of great value to the country, and the Company will accept the trust and the responsibility of its execution in good faith, and will release the Government from any or all claims for royalties incidental to the use of its patents at this place."

The sequel to this, and similar tenders with like guaranties, indicated so plainly that the policy of past administrations was not to

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* Terms of the law authorizing the Secretary to make such contracts.

Mr. Haupt. encourage the letting of contracts to extrinsic parties, however guaranteed, that the Reaction Jetty Company was dissolved.

The changes on the bar during the past 10 years have served to confirm the predictions made to the Board of 1902 as to the probable effects of the Government plan, and the elaborate report submitted at that time only alluded to the offer of the Company in a single paragraph as follows:*

> "The Board knows of no plan for the improvement of this entrance that has not contemplated one or two jetties extending continuously seaward from the points of the entrance that are fixed in position naturally or artificially. The turbulence of the bar is such that operations from floating plant have never been seriously considered as practicable, and any work must be executed from a structure built out from the shore. Even the structure proposed by the Reaction Jetty Company, while nominally a detached breakwater, is in effect an extension of the old jetty, * * *."

This was the only reference, and the extension of the south jetty, as since constructed, was recommended, notwithstanding the following statements in the report:

> "The Board cannot expect that an advance of the bar at this point will not follow the construction of the jetties and the removal of the large quantity of sand necessary to secure a 40-ft. channel. Such advances have invariably been found in all jetty harbors."

But it is expected that:

> "The waves and strong littoral currents have at this point their maximum effect, in retarding and counteracting the bar advance, and, unless the history of the past 60 years is misleading, that advance will be speedily checked and probably reversed with a return of the outer bar slope toward its present location."

These hopes do not appear to have been justified by the results in the later reports, and the question arises as to whether or not there may ever be a better solution than the two-jetty plan, which, it is conceded, "invariably" advances the bars in "all" cases. The answer may be suggested by the experience at Aransas Pass during the operation of the partial reaction breakwater, which not only prevented bar advance but caused a recession of the outer contours until the channel was cut entirely through, without injury to the structure, by a feeble diurnal tide. There are many other elements in this report of the Board of 1902-03 which are worthy of consideration, but space and time prevent the writer from mentioning them.

It is hoped that these suggestions may open the door to a broader consideration of the policies and possibilities of this nation for removing physical obstacles to international trade, and be of greater economic advantage to all people.

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* Report, Chief of Engineers, U. S. A., 1902, p. 2305.

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PAPERS AND DISCUSSIONS

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TUFA CEMENT, AS MANUFACTURED AND USED ON THE LOS ANGELES AQUEDUCT.

Discussion.*

By Messrs. J. M. O'Hara, L. J. Le Conte, and Ralph J. Reed.

J. M. O'Hara, Assoc. M. Am. Soc. C. E. (by letter).—According to Professor Eakle, of the University of California, the rock ground with the cement used on the Los Angeles Aqueduct, is a rhyolite-tuff and a trachyte-tuff, which, when finely ground, will possess the same characteristics as finely ground clay. Mr. O'Hara.

The cement produced by the method used at Monolith and Haiwee, Cal., is similar to cement adulterated with clay. Rhyolite-tuff and trachyte-tuff are not to be confounded with the volcanic rocks known as puzzuolana and trass, which have been used for the manufacture of cement. Puzzuolana and trass are the hardened products of volcanic action in their original state, in which respect they are similar to blast-furnace slag. On the other hand, the volcanic tuff of the nature found at Monolith and Haiwee, is not comparable to blast-furnace slag, being more of the nature of altered volcanic rock.

In Professional Paper No. 28, issued by the United States Government, through the Corps of Engineers, it is stated:

> "Puzzolan cement never becomes extremely hard like Portland, but Puzzolan mortars and concretes are tougher or less brittle than Portland. * * * It is unfit for use when subjected to mechanical wear, attrition, or blows. It should never be used where it may be exposed for long periods to dry air, even after it is well set. It will turn white and disintegrate, due to the oxidation of its sulphides at the surface under such exposure."

A series of tests made at the Ohio State University, under the direction of Professor C. E. Sherman, seems to prove that clay, up

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* This discussion (of the paper by J. B. Lippincott, M. Am. Soc. C. E., published in October, 1912, *Proceedings*, and presented at the meeting of December 4th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. O'Hara. to 15% of the weight of the sand, adds strength to the mortar. One plausible explanation for this increased strength is that the addition of smaller particles of material aids in filling the voids in the sand. One detrimental result was definitely established, namely, that mortars made from sand carrying clay could not be placed under water safely, because the clay softened and warped under its influence.

Mr. Lippincott states:

> "As tufa cements are high in silica, and as the silicates of lime are the more enduring but slower portion in the cements, this growing strength in tufa cement is quite rational. Straight cements which are slow in hardening show the greatest ultimate strengths, and a high 7-day test is regarded with suspicion."

Tufa and Portland cement, as used on the Los Angeles Aqueduct, is a mechanical mixture, the two materials being blended in equal parts by volume. Under these conditions, no silicates of lime are found, and the gradual increase in strength is not due to the same cause as the slow hardening of a high silica Portland cement.

In setting under water, especially sea water, the lime set free from cement by the action of the water combines with soluble silicates, and maintains the strength of the mass. The percentage of lime set free is small, however, and in the Aqueduct product would not combine with much of the silica. When the concrete sets in air, little or no combination with the tufa will take place, and it is only present as an adulterant.

In the manufacture of Portland cement to-day, the clinker is ground much finer than was the custom some years ago, and the lime factor is higher. Consequently, the calcium silicates hydrate more readily, and ultimate tensile strength is reached at an earlier period. Besides, the flash strength, due to the calcium aluminates or gypsum, should not be mistaken for the final strength, due to the calcium silicates.

A high 7-day strength is not of itself an indication of poor quality in a cement, all other things being normal; it may be an indication of early ultimate strength.

The writer is of the opinion that the trend of the paper, to show that the tufa cement, as made at the Los Angeles Aqueduct, is as good as a Portland cement, is dangerous and without precedent.

Mr. Le Conte. L. J. Le Conte, M. Am. Soc. C. E. (by letter).—The natural property possessed by tufa of combining with the free lime in all Portland cements, is certainly a very great discovery, the full importance of which cannot be over-estimated. This interesting feature is further emphasized by the announcement of Dr. Michaelis that his tests, extending over five years, show conclusively that the addition of tufa to lean Portland cement mortar is valuable in sea-water, this latter being especially important to harbor engineers. In view of the general

Mr. Le Conte.

experience that Portland cement concrete slowly disintegrates in sea-water, Italian harbor engineers usually recommend a mixture of puzzuolana and Portland cement for all concretes exposed to its ravages. In many cases where unit strength and quick setting are uncalled for, they use a mixture of ordinary fat lime and puzzuolana. This shows a tendency to return to the old Roman practice, long before the time of Vitruvius, 14 B. C., and recalls the old adage: "Verily, the footprints of the old Roman engineers are eternal."

The writer's attention was first called to the fact of the falling off in strength of Portland cement briquettes after 1 year, while on the fortifications at and near Fort Point, San Francisco, Cal., in 1895 to 1897. At that time some 350 000 bbl. of European Portland cements had been used. The records showed a general falling off in strength after 1 year, a few samples extending to 10 years. The same feature was noticed in the reports of the Metropolitan Water Board, Boston, Mass., and seems to be the experience everywhere.

The author's experiments, indicating that sand briquettes containing 50% of tufa cement showed marked superiority in ultimate strength over those with straight Portland cement after 6 months, are certainly most encouraging.

Years ago, the writer decided that the well-known "Dyckerhoff" brand of Portland cement was the best in the market, but its use was prohibited by its high cost due to transportation expenses from the works to the seaport. In private works under his charge, he overcame this difficulty with a 1 : 5 : 10 concrete, which gave highly satisfactory results. It would be exceedingly interesting to know how tufa cement in the same proportions would behave.

There seems to be a fad for demanding "sharp coarse sand" in specifications for concrete. This fad is based on the general craze for short-time high tests, and nothing else. Engineers often go to great expense to get good coarse sand to make a high-test record, when, in point of fact, after 3 months, briquettes made with fine beach sand show just as great strength as those made with coarse sand, if not greater; that is, after the expiration of 3 months, all the advantages of using coarse sands have entirely disappeared. The cost of manufacture given by the author is most encouraging, and puts new life into the industry.

The lining of irrigation canals in leaky ground is certainly a most serious question, and all sorts of expedients are being tried to overcome the practical difficulties. The proposed lining with lean concrete seems to be the best solution of the problem. The experiments with Kieselguber are very instructive, and broaden the entire field of investigation.

Mr. Reed.

Ralph J. Reed, Jun. Am. Soc. C. E. (by letter).—It is obvious that, on account of finer grinding and consequently better mechanical

Mr. Reed. combinations with other aggregates, tufa cement must make a more dense and impervious concrete. It would have been interesting to have presented some experimental data showing comparisons between the permeability of straight Portland cement concretes and those made with tufa Portland cement. Doubtless experiments along these lines have been carried on in the Los Angeles aqueduct laboratories.

The writer wishes to bear witness to the excellent appearance in general of the concrete work on the aqueduct. A large portion of this work has been constructed with tufa cement concrete. By far the largest portion of the work has been completed under conditions which those at all familiar with Western deserts will recognize as far from ideal for the most successful concrete work. It has apparently been difficult at many points to obtain first-class aggregates. Water for sprinkling the finished work has been hard to supply, and, in fact, the many difficulties encountered are appreciated only by those connected most closely with the work. The writer has been especially impressed with the freedom from cracks shown by the finished tufa cement concrete work in tunnels, open and covered conduits, and especially in the large reinforced concrete siphons referred to by Mr. Lippincott.

That the tufa cement must be handled with greater care during drying is apparent from the fact that in the vicinity of open manholes along the covered conduit in the Mohave Desert, where the concrete during the later stages of drying has been exposed to the sun, cracks are frequent. A little farther back, where the atmosphere has been humid on account of water left standing in the conduit, very few cracks are noticeable. In the tunnels, where the atmospheric conditions and especially humidity have been most completely in control, the tufa concrete lining is dense, hard, and tough, and rarely shows any cracks.

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PAPERS AND DISCUSSIONS

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THE ECONOMIC ASPECT OF SEEPAGE AND OTHER LOSSES IN IRRIGATION SYSTEMS.

Discussion.*

By Messrs. L. J. Le Conte and W. C. Hammatt.

Mr. Le Conte.

L. J. Le Conte, M. Am. Soc. C. E. (by letter).—The curable and incurable losses of water in an irrigation system are certainly worthy of the most careful study and judicious consideration. The loss due to leakage from the reservoir bed is usually regarded as incurable, nevertheless, the site ought to be most carefully examined, geologically, before it is finally accepted.

Experience everywhere shows that when a large storage reservoir is built, the knowing ones always buy the water rights on the adjoining stream on the lower side. They know from experience that the leakage from the reservoir will swell the run-off of the adjoining stream. Where the stratification dips naturally from the reservoir site toward the stream in the adjoining water-shed, the leakage may be very serious. A notable case is that of the River Glyde, in Ireland, where the rainfall and run-off were being carefully observed by able engineers. Observations for 3 months in the rainy season showed a rainfall of 5.89 in. and a run-off of 9.35 in. This result gave rise to a great deal of merriment, at the time, but subsequent observations proved that the flood-waters from the higher adjoining water-shed found underground passages and escaped into the Glyde water-shed, thus swelling the observed run-off to abnormal dimensions. This was discovered by putting coloring matter in the upper stream and noting its appearance in the waters of the Glyde at a lower level, where the gaugings were being made. This simple experiment explained the whole mystery.

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* This discussion (of the paper by E. G. Hopson, M. Am. Soc. C. E., published in October, 1912, *Proceedings*, and presented at the meeting of December 4th, 1912), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. Le Conte. This only goes to show how fallacious it is to assume that the run-off records show all the water that naturally comes from the direct water-shed. In point of fact, a large percentage of it may come from an indirect water-shed. A notable case is that of the Danube River; observations at the Iron Gate show that a large percentage of the summer flow goes through subterranean channels, and swells the summer flow of another stream in an adjoining water-shed.

It is quite common in every-day practice to pick out a dam site where a dike cuts across the valley, the presumption being that all danger of underground flowage is thereby avoided. This is true, but, at the same time, it makes a fine face for leakage to run along over and into the adjoining water-shed.

Mr. Hopson's estimate of a loss of 55% seems to be extravagant. In designing new works, it is generally customary to allow for a loss of one-third of the total, two-thirds of the water being delivered at its final destination. Of course, when the canals are first opened to service, the loss is very great (fully 55 to 60%); but it gradually grows less and less as the channels silt up. Shortly after the works are opened, the maintenance force begins the work of puddling the canal beds. This, of course, is usually done at times when the water is least needed for irrigation, and duties are not pressing. This puddling is kept up each year, until it is completed, when the total loss from seepage and evaporation is generally reduced from 60 to 33⅓%, but as low as 25% in some cases. In a majority of cases, the quantity of water saved by the canals being lined or unlined, but puddled, as usual, is not to exceed 25% at best, and may be much less; hence, lining is certainly questionable. Of course, in all cases where water is highly valuable, the scheme of lining the canals is entirely feasible and desirable; but, in pioneer countries which are being developed, the first cost is practically prohibitive, and, as a rule, that work is left to future generations.

The important point made by the author, however, that the cost of an unlined canal system and a lined canal system will be practically the same, certainly calls for full investigation. At present the writer is unable to see it in the light presented. The author also calls attention to the great saving in drainage troubles, brought about by a general and complete system of lined canals, laterals, and distributing ditches. There seems to be little doubt that the drainage troubles would be greatly mitigated; at present, they constitute the most distressing feature of irrigation works, the unsanitary conditions created and developed by the best types being notorious.

In most cases surface and sub-drainage take care of themselves. The natural drainage channels should be used for that purpose exclusively. They should be cleaned out and some little money should be spent in deepening, straightening, and correcting any natural defects.

Mr. Le Conte.

The lamentable effect of excessive irrigation, on the one hand, and defective drainage, on the other, are beyond ordinary comprehension. When all the facts of any case are properly grasped, the drainage problem naturally develops into a veritable sink-hole for the waste of public money; hence the necessity for the exercise of the highest grade of good judgment.

In India the British Government was compelled to pass the most drastic laws to control irrigation.* On sanitary grounds, no water is allowed to be issued for autumn crops nearer than:

5 miles from a military post.
1 mile " " native town of more than 10 000 inhabitants.
$\frac{1}{2}$ " " " " " " " " 5 000 "
$\frac{1}{4}$ " " " " " " " " 1 000 "
200 yd. from small villages.

Mr. Hammatt.

W. C. Hammatt, M. Am. Soc. C. E. (by letter).—The question brought out in this excellent paper is of great interest to irrigation engineers. It is really, however, a business proposition, as to how much expense is justifiable for the purpose of preventing, or diminishing, the losses and damage due to seepage from canals and ditches. Into this determination enter so many factors, that no rule or formula, however complex, can be made to cover the subject.

The quantity of seepage from canals has been the subject of many investigations, and is dependent on many conditions, which conditions will affect its cure. The writer knows of cases where, at certain seasons of the year, the seepage into a reservoir from its water-shed more than offsets the evaporation therefrom, so that the reservoir remains practically stationary under a 120° sun.

In both reservoirs and canals, the seepage loss is dependent on the depth of water in the canal, the breadth of the wetted perimeter, the soil through which the canal is excavated, the kind of subsoil and the distance thereto, the height of the ground-water, the slope of the country, the growth of weeds in the canal, the character of the vegetation outside of the canal, and many other factors. All water which seeps from the canal can be accounted for and traced to its destination. In some cases it has a flow through the soil, in a definite direction and at a determinable speed, toward some open watercourse or underground reservoir. The character of the soil through which the canal is cut may make a variation in the rate of seepage of from 0.3 to 1.6 vertical ft. per day—the limits of measurements made by the writer. Aquatic grasses and weeds require water for their growth, aid seep-

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* See discussion by Surgeon-General H. W. Bellew on paper "The Evils of Canal Irrigation in India, and Their Prevention," by T. H. Thornton, *Journal*, Society of Arts, Vol. XXXVI, p. 521 (Mar. 23d, 1888); and "The Injurious Effects of Canal Irrigation on the Health of the Population of the Punjab, and Their Remedy," by Surgeon-General H. W. Bellew, *Journal*, Society of Arts, Vol. XXXVI, p. 640 (May 11th, 1888).

Mr. Hammatt. age by loosening the soil and facilitating the passage of water to the subsoil, and increase evaporation through their leaves. Measurements under the supervision of the writer have shown this to increase the natural seepage as much as 40 per cent. A certain quantity of seepage goes to supply the wants of near-by vegetation, thus creating a flow and a gradient in that direction.

The seriousness of the loss by seepage depends on various causes, among which are the following: The scarcity of water and consequent loss in crop value, due to lack of the quantity lost by seepage; the character of the soil, and the consequent tendency toward the rise of the ground-water; and the character of crops, and the effect on them of a high or low water-table.

In Southern California, where water is scarce and the crops consist mainly of citrus fruits, the value of the water for crop propagation will pay for an immense expense for seepage prevention. On the other hand, in Central California, where water is plentiful and the crops are grain, cereals, and alfalfa, and $5 per acre per year is a prohibitive price for water, very little expense for the prevention of losses is justifiable. It is seldom that the seepage from a canal is sufficient to water-log the soil. At the maximum rate the writer has seen, namely, 1.6 vertical ft. in 24 hours, the seepage from a canal carrying 100 sec-ft. would be about sufficient per mile to raise the ground-water 1 ft. in 900 acres. As the 100 sec-ft. would irrigate about 16 000 acres, and as only about 10% of this would go toward crop propagation, the remainder staying in the soil, the small proportion of ground-water due to canal seepage is apparent. Consider also that the farmer's tendency is to over-irrigate, especially where water is sold at a flat price per acre without regard to the quantity used, and we have the reason for the drowning of so many good farming areas.

B. A. Etcheverry, Assoc. M. Am. Soc. C. E., has made a great study of various linings for canals and ditches.* The data which he has compiled show a maximum cost of lining of about 6 cents per sq. ft., and this is for thin mortar lining which is only adaptable to canals in solid ground' capable of resisting the pressure, and with no possibility of settlement. In most of the canal systems of Central California, the cost of the entire system, exclusive of the preparation of the land itself, has fallen to between $10 and $25 per acre of irrigated land. The cost of lining only the main canals and branches would raise the cost of the systems from 25 to 50%, which would only be justified by a continued scarcity of water.

The writer has only discussed the lining of canals for the prevention of seepage losses. Where the point of diversion is so much

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* These data may be found in *Bulletin No. 188*, Agricultural Experiment Station, University of California, and in *Bulletin No. 44*, Department of Agriculture, Victoria, B. C.

Mr. Hammatt.

above the point of use of the water that a steep grade and a swift flow is obtainable, the lining of the canal—by reducing the coefficient of roughness and by increasing the allowable velocity—will reduce the section sufficiently to repay its cost, partly, if not wholly. Another element is the growth of weeds, which would be eliminated by a concrete lining.

To summarize: The question as to the lining of canal systems should be decided by balancing, against the cost of such lining, the value of the water lost, the damage done by that water, the cost of excavation and of structures saved, and the elimination of the cost of canal cleaning.

AMERICAN SOCIETY OF CIVIL ENGINEERS
INSTITUTED 1852

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications.

SPECIFICATIONS FOR METAL RAILROAD BRIDGES MOVABLE IN A VERTICAL PLANE.

Discussion.*

By Augustus Smith, M. Am. Soc. C. E.

Augustus Smith, M. Am. Soc. C. E. (by letter).—The writer desires to add his acknowledgment of the value of the specifications for movable bridges,† by C. C. Schneider, Past-President, Am. Soc. C. E., and of the discussions contributed by other members of the Society on that subject. There was great need for definite specifications, and Mr. Leffler's valuable contribution is another important gift to the Profession. Mr. Smith.

The writer is glad to discuss a few of the details defined so unequivocally by the author, taking them up in order, as follows:

Paragraph 55.—The author apparently favors the use of tapered keys, but obviously could not attempt, in the text of a specification, to give any justification for this preference. Without rehearsing the arguments against tapered keys,‡ the writer would call attention to the fact that they cost more than straight keys and require considerable room on the shaft for each wheel fitted, so that it is not practicable to place a wheel close to a bearing, and, when such keys are used, it is not practicable to place two or more wheels very close together. In some cases tapered keys are necessary. The writer's practice is to use straight keys where possible, and tapered keys where straight ones are not practicable.

Paragraph 92.—Worm gearing is used frequently for transmitting power, where it is desirable to hold the load. If the angle of the

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* This discussion (of the paper by B. R. Leffler, M. Am. Soc. C. E., published in October, 1912, *Proceedings*, but not presented at any meeting), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

† *Transactions*, Am. Soc. C. E., Vol. LX, p. 258.

‡ Summarized in Kent's "Mechanical Engineer's Pocketbook."

Mr. Smith. thread for the worm were 20° or more, the wheel would be able to turn the worm backward. There are not many data on the limiting angle of thread which will give the maximum efficiency of a worm drive without being steep enough to permit the wheel to drive the worm. The writer has found the angle to be approximately 6°, but much depends on the nature of the thrust bearing holding the worm, and the angle would be less if first-class ball bearings were used.

Paragraph 136.—The author allows for the bending stress in the individual wires of rope bent around a sheave, and points out that this is a function of the diameter of the individual wires and not directly of the diameter of the rope, as it is sometimes apparently thought to be. The same thing has been worked out by the engineers of the Trenton Iron Company.* Attention is called to the fact that the minimum diameter of sheaves and drums given in the lists of all manufacturers of wire ropes has been apparently agreed on, like the price list, but it is not altogether consistent with the foregoing theory.

The writer confesses to some obtuseness in his power of conception of the action of cumulative stresses. If the bending stress in the wires is really added to the tensile stress produced by the load on the rope, an overloaded rope should always break on a sheave or drum, and not in a straight part.

Paragraph 140.—The author's formula for determining the strength of gear teeth follows the general form advocated by Mr. Lewis, namely, by making the allowable pressure proportionate to the pitch and face multiplied together, instead of the earlier formula given by Tredgold, in which the pitch was squared. The author's formula makes due allowance for the number of teeth and the velocity, and is intended to apply to steel gearing, because, according to Paragraph 38, only cast or forged steel should be used for this purpose. He should add a formula fixing the face in terms of the tooth pressure, to provide for wear. Cast iron works with less friction, and usually with less tendency to cut, than cast steel or forged steel when running together, and the writer is doubtful about allowing much greater tooth pressure per inch of face for steel than for first-class close-grained cast iron. It will be observed that the permissible pressure on the contact surfaces between the teeth of gears given in Paragraph 140 is many times greater than that allowed in sliding contact by Paragraph 150. Unwin mentions the old rule that the pressure between teeth should not exceed 400 lb. per in. of face in order to obtain good wearing results. The late James Christie,† M. Am. Soc. C. E., in his discussion of Mr. Schneider's paper, gives a formula naming the working pressure of the tooth in pounds per inch of face, in terms of the pitch multiplied by a constant dependent on the nature of the material, and divided by the square root of the velocity. Mr. Christie's formula, it will be observed, gives higher values for steel than for cast iron, in the ratio of 10 to 6. Mr. Smith.

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* The results are given in the handbooks of that company.

† *Transactions*, Am. Soc. C. E., Vol. LX, p. 318.

Paragraph 157.—The writer would suggest adding to this paragraph a sentence to the effect that when brakes which act through the transmission machinery are used, all parts of that machinery so affected shall be designed to withstand the maximum force set up by the application of the brakes, if it should be more than that of the driving motor.

Paragraph 168.—The author limits the maximum piston speed of internal combustion motors to 350 ft. per min. A comparison of the various speeds given by manufacturers of so-called "heavy-duty" motors would indicate an allowable piston speed of 500 ft. per min., and even higher. The writer's experience with a gasoline motor indicates perfectly satisfactory results at 500 ft. per min. One objection to putting the piston speed too low in motors of this type is the inevitable leaks past the piston rings, and at low speeds there is a marked loss in compression around the valves, so that an internal combustion engine does not develop the proportional power at a low speed that it would at a higher speed.

The writer would also recommend adding a provision to this paragraph limiting the ignition, if electric, to the jump-spark method, and would also advocate specifying the use of a jump-spark apparatus in which the secondary coil is made up on each spark plug as part of it, so that a low-tension current of 6 or 10 volts at the outside is all that would have to be taken care of in the wiring. He would recommend a clause prohibiting the use of any internal combustion motor in which cooling water was passed through a packing or joint designed to withstand the gases of combustion. This provision, in the case of engines in which the cylinder head is made separable from the body of the cylinder, would require the cooling water to be by-passed outside from the cylinder to the head, or brought to and from the head and cylinder separately. Preference should be given to an air-cooled motor of proven reliability.

Paragraph 177.—In this paragraph the author names the spare parts to be furnished with an electric motor. The writer thinks that certain spare parts, such as igniters and crank-pin brasses, would be advisable in the case of internal combustion motors.

Paragraph 180.—The author specifies controllers of the reversible drum type, and while these give very good results, the writer has found that controllers of the disk type, such as are made by the Electric Controller and Manufacturing Company, give equally satisfactory results in hoisting and crane service, so that he would not advise limiting controllers to the drum type.

In the discussion of Mr. Schneider's paper a number of leading

Mr. Smith. designs of bascule bridges were brought out. Though it has no direct bearing, as part of this discussion, it might be of interest at this time to add to the various bridges brought out by Mr. Schneider's paper, a design which the writer prepared for the Stone Bridge, at Tiverton, for the State of Rhode Island, based on the old Delille type of fortification draw-bridge.

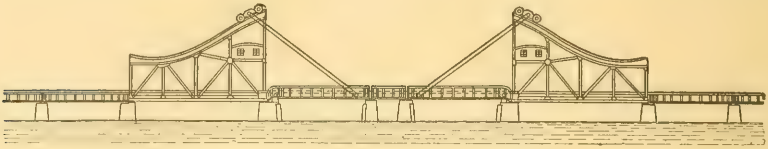

Fig. 3.

The mechanical principles involved in this bridge are obvious from Fig. 3. The advantage of the stiff connecting link between the moving bascule and the counterweight is that the bridge can be balanced at all points and forced down against a wind pressure. Another advantage is that the spans on which the counterweight moves can be used frequently as through truss spans, like approach spans, on each side of the draw, with some economy in metal. A third feature is that all the moving parts are high above the water, and cannot be affected by salt spray or ice. In common with many others of the bascule type, a low-level bridge is possible, and no expensive foundations for counterweight or the like are necessary. Another advantage—and it seems to the writer a very important one—is that this bridge, especially where a double-leaf bascule is used, has a more pleasing architectural effect than is commonly the case with bascule bridges.

In the Tiverton Bridge, which was designed for highway and trolley car service, no central pier was used, but the connecting rods were made of very ample cross-section so as to reduce the deflection of the bridge at the center to a negligible amount for the purpose. For railway service, a center pier of some sort would doubtless be desirable; such a pier would be built in the middle of a two-leaf span with less obstruction to traffic than would be the case if a swinging draw were used.

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PAPERS AND DISCUSSIONS

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THEORY OF REINFORCED CONCRETE JOISTS.

Discussion.[*]

By Ernest McCullough, M. Am. Soc. C. E.

Mr. McCullough.

Ernest McCullough, M. Am. Soc. C. E. (by letter).—In some recent correspondence with Sanford E. Thompson, M. Am. Soc. C. E., the writer's attention was called to a too common error on the part of designers in reinforced concrete, wherein the sum of the middle bending coefficient and the coefficient at one support is always assumed to be equal to $\frac{1}{8} wl^2$. The moment of inertia of the section is not considered as being affected by the quantity of steel, the result being that, if a middle coefficient $= \frac{1}{10}$ is assumed, the coefficient over supports is taken as $\frac{1}{40}$. The writer checks a great many plans for contractors and owners, these plans being generally furnished free of cost by steel salesmen. The almost uniform practice is to use the clear span, face to face of T-beams, for floor slabs, and the clear span, face to face of columns, for beams and girders, the foregoing coefficients being used for steel distribution. The writer has never been able to make the designers do more than use a coefficient of $\frac{1}{12}$ in the middle and $\frac{1}{24}$ over supports. He has sometimes failed to secure a concession of even that much, as the designers can refer owners to a large number of buildings, erected in every State in the Union, designed with the foregoing dis-

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[*] This discussion (of the paper by John L. Hall, M. Am. Soc. C. E., published in October, 1912, *Proceedings*, but not presented at any meeting), is printed in *Proceedings* in order that the views expressed may be brought before all members for further discussion.

Mr. McCullough. tribution of bending coefficients. When possible, he compels the use of $\frac{1}{12}$ over supports and $\frac{1}{18}$ in the middle, whereas, the building ordinances of Chicago and most cities call for a total of $\frac{1}{6}wl^2$, with a coefficient of $\frac{1}{12}wl^2$ in the middle, of course, then obtaining equal steel areas in the middle and over each support.

Two weeks ago a designer gave as authority for his method, Turneaure and Maurer's "Principles of Reinforced Concrete Construction," second edition, page 307, where the following occurs:

"* * * but the use of $\frac{1}{10}$ for the general coefficient will provide ample strength in all ordinary cases. This would require an actual resisting moment at each support of only about $\frac{1}{40}pl^2$ in order that the center moment be reduced to $\frac{1}{10}pl^2$."

His attention was called to a line on the same page where the following appeared:

"The foregoing calculations assume uniform moment of inertia and therefore that about the same amount of steel is used for negative as for positive moments. The effect of variation in moment of inertia is discussed in Art. 166."

In the preceding paragraph, on the same page, the authors propose certain coefficients, saying plainly that they are for both positive and negative moments. To the writer, it seems impossible to make any mistake in the matter, if it is carefully studied, even with no other authority than that above quoted.

Turning to Art. 166 in the above-mentioned book, it is found to deal with columns, the reference being a misprint, Art. 165 being meant. This section is a valuable discussion of the effect of varying moments of inertia, being based, for the most part, on a discussion by P. E. Stevens, Assoc. M. Am. Soc. C. E.* A table is given, based on the moments of inertia varying with the quantities of steel, showing that if the assumption be made that the middle coefficient $= \frac{1}{8}wl^2$ and about one-fifth of the quantity of steel in the middle in the bottom be placed in the top over supports, the stress at the center will be 55% of the working stress and at the end will be $4.1 \times 0.55 = 2.25$ times the working stress.

In the last edition of "Concrete, Plain and Reinforced," by Taylor and Thompson, the following is found on page 439:

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* *Transactions*, Am. Soc. C. E., Vol. LX, 1908, p. 496.

Mr. McCullough.

"In applying this to the various cases, the assumption is made that the moment of inertia of the beam is constant throughout its length. While this is not strictly true, extensive studies of various cases in reinforced concrete show that a large change in the moment of inertia makes a very small change in the bending moment, so that the relations are substantially correct until a member enters a much larger member."

Mr. Thompson, in a letter to the writer, says:

"Many designers have the very erroneous idea that, because they design a beam for $\frac{wl^2}{8}$, the bending moment is reduced to zero over the supports. This, of course, is not the case, because designing the beam for $\frac{wl^2}{8}$ is an entirely different matter from changing the bending moment to $\frac{wl^2}{8}$. The bending moment still remains in the neighborhood of $\frac{wl^2}{24}$, if the beam is fully continuous; so that the bending moment at the support for uniform load is still a little less than $\frac{wl^2}{12}$."

In his paper, Mr. Hall has placed the matter in the proper light, but has neglected to call attention specially to the fact that all concrete designs, wherein continuity of construction is considered, should be based on the end moments rather than the center span moments.

A few days ago, in conversation with three structural engineers, members of this Society, the writer discovered, to his surprise, that they believed the sum of the center and one end coefficient $= \frac{1}{8}$; and if the assumption is made for a large bending moment in the center, that only enough steel is required over supports to care for the remainder of the coefficient, it being their practice to use arbitrarily over supports about one-fifth of the quantity of steel used in the middle, in the event that they use $\frac{wl^2}{8}$ in the center. This small quantity of steel they claim is to take care of possible cracks, mainly caused by temperature, and possibly by a bending down of the flanges of T-beams, or unlooked for variations in loading. As such men hold to these views, it is proper to have a full discussion of this phase of the subject, and that some present methods of designing be discouraged. Five or six years ago such views were common, and it is surprising that by this time so many men of standing in concrete work still neglect consideration of the fact that "designing the beam for $\frac{wl^2}{8}$ is an entirely different matter from changing the bending moment to $\frac{wl^2}{8}$," as stated by Mr. Thompson.

620.6

AMERICAN SOCIETY

OF

CIVIL ENGINEERS

Instituted November 5, 1852

CONSTITUTION AND LIST OF MEMBERS

FEBRUARY 10th, 1912

House of the Society, 220 West Fifty-seventh Street,
NEW YORK.

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HOUSE OF THE SOCIETY,

220 West 57th Street

Cable Address:
"Ceas, New York."

Telephone:
5913 Columbus.

CALENDAR

1912-13

DATES OF MEETINGS IN BOLD-FACED TYPE

FEBRUARY, 1912

S	M	T	W	T	F	S
..	..	..	..	1	2	3
4	5	6	**7**	8	9	10
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MARCH

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APRIL

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JUNE

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JULY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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1	2	3	**4**	5	6	7
8	9	10	11	12	13	14
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JANUARY, 1913

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NOTE.—Regular meetings are called to order at 8.30 P. M.

The House of the Society is open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

The Annual Convention will be held at Saratoga, N. Y. At the time of going to press the date had not been fixed.

CONSTITUTION

ADOPTED MARCH 4TH, 1891.*

ARTICLE I.—NAME, LOCATION AND OBJECT.

1.—The name of this Association shall be the AMERICAN SOCIETY OF CIVIL ENGINEERS.

2.—The offices of the Society shall be located in the City of New York.

3.—Its objects shall be the advancement of engineering knowledge and practice and the maintenance of a high professional standard among its members.

4.—Among the means to be employed for this purpose shall be: meetings for the presentation and discussion of appropriate papers and for social and professional intercourse; the publication of such papers and discussions as may be deemed expedient; the maintenance of a library, the collection of maps, drawings and models, and the establishment of facilities for their use.

ARTICLE II.—MEMBERSHIP.

1.—The Corporate Members of this Society shall be designated as Members and Associate Members. There may also be connected with the Society, Honorary Members, Associates, Juniors, and Fellows who shall be entitled to all the privileges of the Society, except the right to vote and to hold office therein; provided that Honorary Members elected from the Corporate Members of the Society shall retain their right to vote and to hold office.

2.—A Member shall be a Civil, Military, Naval, Mining, Mechanical, Electrical, or other professional Engineer, an Architect or a Marine Architect. He shall be at the time of admission to membership not less than thirty years of age, and shall have been in the active practice of his profession for ten years; he shall have had responsible charge of work for at least five years, and shall be qualified to design as well as to direct engineering works. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice. The performance of the duties of a Professor of Engineering in a technical school of a high grade shall be taken as an equivalent to an equal number of years of actual practice.

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* Amended October 3d, 1894; March 6th, 1895; October 6th, 1897; October 5th, 1898; October 3d, 1900; March 4th, 1903; October 7th, 1903; October 7th, 1908, and March 1st, 1911.

3.—An Associate Member shall be a professional Engineer or Architect not less than twenty-five years of age, who shall have been in the active practice of his profession for at least six years, and who shall have had responsible charge of work as principal or assistant for at least one year. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice.

4.—Any person having the necessary qualifications prescribed in this article to entitle him to admission to the grades of Member or Associate Member, shall be eligible for such membership, though he may not be practicing his profession at the time of making his application.

5.—An Associate shall be a person who, by scientific acquirements or practical experience, has attained a position in his special pursuit qualifying him to co-operate with engineers in the advancement of professional knowledge and practice, but who is not a professional engineer.

6.—A Junior shall not be less than eighteen years of age, and his connection with the Society shall cease when he becomes thirty-two years of age, unless he be previously transferred to another grade. He shall have had active practice in some branch of engineering for at least two years, or he shall have graduated from a school of engineering of recognized standing. Persons who are in the Junior class at the time of the adoption of this Constitution shall not have their status changed by the provisions of this section.

7.—Honorary Members shall be chosen only from persons of acknowledged eminence in some branch of engineering or the sciences related thereto. There shall not be more than twenty at any one time.

8.—Fellows shall be contributors to the permanent funds of the Society, though they may not be eligible for admission as Corporate Members.

ARTICLE III.—Admissions and Expulsions.

1.—Honorary Members shall be proposed by at least ten members, and shall be elected only by a unanimous vote of the Board of Direction. A Past-President, or a member of the Board of Direction proposed for Honorary Membership, shall not be required to vote either for or against his own admission.

A person elected an Honorary Member shall be promptly notified thereof by letter. The election shall be cancelled if an acceptance is not received within six months after the mailing of such notice.

All members other than Honorary Members shall be admitted to the Society only by vote of the Board of Direction, as hereinafter specified.

2.—An application for admission to the Society or for transfer from one grade to another shall embody a concise statement, with dates, of the candidate's professional training and experience; and shall be in a form and in such detail as may be prescribed by the Board of Direction. It shall be signed by the applicant, and shall contain a promise to conform to the requirements of membership, if elected. The applicant shall furnish the names of at least five Corporate Members to whom he is personally known. Each of these shall be requested by the Secretary to address a letter to the Board of Direction, on a form prescribed by said Board, stating the extent of the writer's personal knowledge of the applicant and of his professional work. If at least five of the Corporate Members named as references do not furnish the requisite endorsement, the Secretary shall call upon the applicant for additional names, and not until written communications shall have been received from at least five Corporate Members shall the application be considered by the Board.

Applications of engineers not resident in North America, and who may be so situated as not to be personally known to five Corporate Members, may be recommended for ballot by five members of the Board of Direction, after having secured evidence sufficient, in their opinion, to show that the applicant is worthy of admission.

3.—At stated periods, to be determined by the Board of Direction, there shall be issued to each member in any grade whose address is known, a list of all new applications received for admission or for transfer, which list shall be dated and shall contain a concise statement of the record of each applicant and the names of his references, with a request that members transmit to the Board any information in their possession which may affect the disposition of the applications. Not less than twenty days after the issue of such list, the Board of Direction shall consider these applications, together with any information in regard to the applicants that may have been received; may make further inquiries, if deemed expedient; shall classify the applicant with his consent, and on applications for admission shall vote thereon by ballot.

The Board shall have the power to elect persons to any grade, and to transfer persons from any grade to a higher grade of membership, and shall notify the membership of its action.

4.—The ballots shall be letter-ballots, in a form to be prescribed by the Board of Direction. They shall be mailed to each member of the Board of Direction, and shall state the date on which the ballot is to be canvassed, which shall be not less than twenty days after the issue of the ballot. At least twenty-five votes must be cast to constitute an election. Three or more negative votes shall exclude from election. In case of exclusion, no notice thereof shall be entered on the minutes, but the candidate shall be notified.

A rejected applicant may renew his application for membership or transfer at any time after the expiration of one year from the date of the ballot rejecting his previous application.

5.—All elected candidates shall be duly notified and shall subscribe to the Constitution and Rules of the Society. Forms for these purposes shall be prescribed by the Board of Direction. If these provisions are not complied with within six months from the notification of election, such election shall be considered void unless for special reason the time shall be extended by the Board of Direction.

Membership of any person shall date from the day of his election.

6.—Upon the written request of ten or more Corporate Members, that for cause therein set forth a person belonging to the Society be expelled, the Board of Direction shall consider the matter, and if there appears to be sufficient reason, shall advise the accused of the charges against him. He may, if he so desires, present a written defence which shall be considered at a meeting of the Board of Direction, of which he shall receive due notice. Not less than two months after such meeting, the Board of Direction shall finally consider the case, and if resignation has not been tendered, or a defence made which is satisfactory to the Board, it shall then notify the person that he will be expelled in one month, unless he elects to appeal from this decision. Appeals will be submitted to the Corporate Members by letter-ballot in a form to be prescribed by the Board of Direction. The ballot shall be accompanied by a statement of the charges, and of the action of the Board thereon, with such information as it deems proper, and also the statement of the person making the appeal. The ballot shall be canvassed by the Board not less than twenty days after its issue. A majority of the ballots cast will be required to sustain the action of the Board. The Board will notify the person and the Corporate Members of the result of the ballot. In case no appeal be made, the Board of Direction will expel the person, and notify him and the Corporate Members of its action.

7.—A member of any grade in the Society may resign his membership by a written communication to the Secretary, who shall present the same to the Board of Direction; when, if all his dues have been paid, his resignation shall be accepted.

8.—All persons elected and duly qualified, whose address on the records of the Society is within fifty miles of the Post Office in the City of New York, shall be deemed Resident; and those whose address is beyond that limit shall be deemed Non-Resident.

The classification of each person for the fiscal year as Resident or Non-Resident, shall be determined by the Records of the Society as they may appear on January 1st of that year.

ARTICLE IV.—Dues.

1.—The entrance fees payable on admission to the Society shall be as follows: by Members, thirty dollars; Associate Members, twenty-five dollars; Associates, twenty dollars; Juniors, ten dollars.

2.—The annual dues payable by members, whether Resident or Non-Resident, shall be as follows: by Corporate Members, fifteen dollars; Associates, ten dollars; Juniors, ten dollars.

3.—In addition to the dues prescribed in the preceding section, each Resident Member shall pay annually as follows: Corporate Members, ten dollars; Associates, five dollars; Juniors, five dollars.

4.—A person transferred from any grade to a higher one shall pay the difference between the entrance fees of the two grades, and his annual dues shall be those of the higher grade.

5.—The annual contributions shall become due for the ensuing year on the first day of January, and shall be payable in advance. It shall be the duty of the Secretary to notify each member of the amount due for the ensuing year at the time of giving notice of the Annual Meeting.

6.—Persons elected after six months of any fiscal year shall have expired, shall pay only one-half of the amount of dues for that fiscal year.

7.—All future annual dues may be compounded by a single payment by a Corporate Member of $250; or by an Associate of $150. Should a compounding Associate be elected to Corporate Membership he shall pay the further sum of $100.

Provided, that all compounding Corporate Members or Associates who may be or hereafter become Resident, shall be and remain liable for the annual payment of the difference between the annual dues of Resident and Non-Resident Corporate Members, or Associates; but any Corporate Member may at any time compound for the future payment of all annual dues of every nature and kind by the payment of $75 in addition to the $250 hereinbefore named; and any Associate may at any time compound for the future payment of all annual dues as Associate by the payment of $40 in addition to the $150 hereinbefore named.

Provided, that any person desiring to compound for future dues shall have paid his entrance fee, all arrears of dues, and the annual dues for the current year, before the compounding sum may be available.

Persons compounding shall sign an agreement that they will be governed by the Constitution and Laws of the Society as they are now formed, or as they may be hereafter altered, amended or enlarged; and that in case of their ceasing to be connected with the Society from any cause whatever, the amount theretofore paid by them for compounding, and for entrance fees and annual dues, shall be the property of the Society.

All moneys thus paid in commutation of annual dues shall be invested as a permanent fund, only the interest thereupon being subject to appropriation for current expenses.

8.—Any person whose dues are more than three months in arrears shall be notified by the Secretary. Should his dues not be paid when they become six months in arrears, he shall lose the right to vote or to receive the publications of the Society. Should his dues become nine months in arrears, he shall again be notified in form prescribed by the Board of Direction, and if such dues become one year in arrears, he shall forfeit his connection with the Society. The Board of Direction, however, may, for cause deemed by it sufficient, extend the time for payment and for the application of these penalties.

9.—The Board of Direction may, for sufficient cause, temporarily excuse from payment of annual dues any member who from ill health, advanced age, or other good reason assigned, is unable to pay such dues; and the Board may remit the whole or part of dues in arrears, or accept in lieu thereof, desirable additions to the Library, or collections.

10.—Every person admitted to the Society shall be considered as belonging thereto and liable for the payment of all dues until he shall have resigned, been expelled, or have been relieved therefrom by the Board of Direction.

11.—Persons elected as Fellows shall become such upon the payment of Two Hundred and Fifty dollars into the permanent funds of the Society. They shall not be liable for other fees and dues.

12.—The status of any present subscribers shall not be changed by the provisions of this Constitution.

13.—Corporate Members and Associates who have reached the age of seventy years, and who have paid dues as such for twenty-five years, shall be exempt from further dues. Corporate Members and Associates who have paid dues as such for thirty-five years shall be exempt from further dues.

ARTICLE V.—Officers.

1.—The officers of the Society shall be a President, four Vice-Presidents, eighteen Directors, a Secretary, and a Treasurer, who, with the five latest living Past-Presidents, who continue to be members, shall constitute the Board of Direction in which the government of the Society shall be vested, and who shall be the Trustees as provided for by the laws under which the Society is organized. For the election of Honorary Members, all the Past-Presidents shall be members of the Board of Direction, except any Past-President who may be disqualified by mental or bodily infirmity, and the evidence of said disqualification shall be a written certificate from his attending physician, or some officer of the Society.

2.—The terms of office of the President, Secretary and Treasurer shall be one year; of the Vice-Presidents, two years; and of the Directors, three years. Provided, however, that at the first election after the adoption of this Constitution, four Vice-Presidents and eighteen Directors shall be elected, of whom two Vice-Presidents and six Directors shall be elected to serve for one year only, and six Directors for two years only; provided, also, that after the first election two Vice-Presidents and six Directors shall be elected each year.

The term of each officer shall begin at the close of the Annual Meeting at which such officer is elected, and shall continue for the period above named or until a successor is duly elected.

3.—A vacancy in the office of President shall be filled by the senior Vice-President.

A vacancy in the office of Vice-President shall be filled by the senior Director. Seniority between persons holding similar offices shall be determined by priority of election to the office, and when these dates are the same, by priority of admission to Corporate Membership; and when the latter dates are identical, the selection shall be made by lot. In case of the disability or neglect in the performance of his duty, of any officer of this Society, the Board of Direction shall have power to declare the office vacant. Vacancies in any office for the unexpired term shall be filled by the Board of Direction, except as provided above.

4.—The President shall be ineligible for re-election. The Vice-Presidents and Directors shall not be eligible for re-election to the same office until at least one full term shall have elapsed after the end of their respective terms.

5.—At least one Vice-President, the Secretary and the Treasurer, and six Directors shall be Resident Corporate Members during their term of office.

ARTICLE VI.—MANAGEMENT.

1.—The President shall have a general supervision of the affairs of the Society. He shall preside at meetings of the Society and of the Board of Direction at which he may be present, and shall be *ex-officio* member of all committees. He shall deliver an address at the Annual Convention.

The Vice-Presidents in order of seniority shall preside at meetings in the absence of the President, and discharge his duties in case of a vacancy in the office.

2.—The Board of Direction shall manage the affairs of the Society in conformity to the laws under which the Society is organized and the provisions of this Constitution. It shall direct the investment and care of the funds of the Society; make appropriations for specific purposes; act upon applications for membership as heretofore provided; take measures to advance the interests of the Society; appoint all its employees; and generally direct its business. The Board of Direction shall make an annual report at the Annual Meeting, transmitting the report of the Treasurer and of other officers, and of Committees.

3.—The Treasurer shall receive all moneys and deposit the same in the name of the Society. He shall invest all funds not needed for current disbursements, as shall be ordered by the Board of Direction. He shall pay all bills, when certified and audited, as provided by this Constitution and by rules to be prescribed by the Board of Direction. He shall make an annual report and such other reports as may be prescribed by the Board of Direction.

The Board of Direction shall secure a satisfactory surety for the faithful performance of his duties by the Treasurer, and shall renew the same during the month of January of each year.

4.—The Secretary shall be a Corporate Member of the Society. He shall be elected annually by the Board of Direction at the meeting to be held within twenty days after the Annual Meeting provided for in Section 7 of Article VI, or at an adjournment thereof, and shall hold the office for one year or until his successor is elected, provided that a majority of the whole Board of Direction shall be required to elect the Secretary; this vote to be given, if necessary, by letter.

He shall be, under the direction of the President and Board of Direction, the executive officer of the Society.

He will be expected to attend all meetings of the Society and of the Board of Direction; prepare the business therefor, and duly record the proceedings thereof.

He shall see that all moneys due the Society are carefully collected, and without loss transferred to the custody of the Treasurer.

He shall carefully scrutinize all expenditures, and use his best endeavor to secure economy in the administration of the Society.

He shall personally certify the accuracy of all bills or vouchers on which money is to be paid, and shall countersign the checks drawn by the Treasurer against the funds of the Society, when such drafts are known to him to be proper and duly authorized by the Finance Committee.

He shall have charge of the books of account of the Society, and shall furnish monthly to the Board of Direction a statement of receipts and expenses under their several headings, and also a statement of monthly balances. He shall present annually, to the Board of Direction, a balance sheet of his books, as of the 31st of December, and shall furnish, from time to time, such other statements as may be required of him.

He shall conduct the correspondence of the Society and keep full records of the same.

He shall have charge of the Society's house and its contents; shall supervise the work of all employees of the Society, and see that they diligently perform their respective duties.

He shall perform all other duties which may from time to time be assigned to him by the Board of Direction.

5.—The Board of Direction may also, if they deem it necessary, appoint an Assistant Secretary, who shall aid the Secretary and be under his immediate direction in all matters. His whole time shall be given to the Society.

6.—The Secretary and Treasurer shall be paid salaries to be determined by the Board of Direction; but such salaries shall not be reduced during the term of office, as provided in this Constitution. All other salaries shall be fixed, from time to time, by the Board of Direction.

7.—The Board of Direction shall meet within twenty days after the Annual Meeting, and shall then appoint from its members a Finance Committee of five, a Library Committee of five, and a Committee on Publications of five. At least three members of the Finance Committee, and two members of the other Committees, shall be resident within fifty miles of New York.

These Committees shall report to the Board of Direction, and perform their duties under its supervision.

8.—The Finance Committee shall have immediate supervision of the financial affairs of the Society; shall employ an expert accountant to audit the accounts monthly; shall approve all bills before payment, and shall make recommendations to the Board of Direction as to the investment of moneys, and as to other financial matters.

9.—The Library Committee shall have general supervision of the Library and the House of the Society and the property therein; shall make recommendations to the Board with reference thereto, and shall direct the expenditure for books and other articles of permanent value, of such sums as may be appropriated for these purposes.

10.—The Committee on Publications shall have general supervision of the publications of the Society, and of contracts and expenditures connected therewith.

11.—In the consideration of papers offered for presentation, those papers containing matter readily found elsewhere, those specially advocating personal interests, those carelessly prepared or controverting established facts, and those purely speculative or foreign to the purposes of the Society, shall be rejected. The Committee on Publications shall determine which papers shall be read in full, and which shall be printed after reading by title only. The Committee may return a paper to the writer for correction and emendation, and call to its aid one or more members of special experience relating to the subject treated, either to advise on the paper or to discuss it. Such papers as in the judgment of the Committee should appear in the *Transactions*, shall promptly, upon their acceptance, be printed and distributed to members of all grades; others shall, with the consent of the authors, be suitably indexed, and filed for reference, or the Committee may provide abstracts thereof, which, when approved by the authors, may be published instead of the original papers. Advance copies of papers and discussions may be sent out to the membership before final publication.

12.—Special committees to report upon engineering subjects shall be authorized, except as further provided in this paragraph, by a majority of the votes cast by the Society, and in the following manner: A proposition to appoint such a Committee shall be presented at a regular meeting of the Society, and if sustained, on a motion to refer the same to the Board of Direction, by an affirmative vote of not less than twenty-five Corporate Members, it shall be so referred.

The Board of Direction shall then consider the same and report its recommendations to the Society at the next general business meeting, together with a statement of the arguments for and against the appointment of such Committee.

If a motion for the issue of a letter-ballot thereon receive the affirmative vote of two-thirds of the Corporate Members present, the Board of Direction shall, within thirty days thereafter, issue the letter-ballot, accompanied by a statement of the arguments for and against the proposition.

A majority of a total vote of not less than one-third of the Corporate Membership of the Society shall be necessary for its adoption, whereupon the Committee so authorized shall be appointed by the Board of Direction.

Whenever, in the judgment of the Board of Direction, a special committee, appointed in the above prescribed manner, by reason of the long time required for its appointment, would be defeated in its object and be of no avail, then the Board of Direction shall be authorized to appoint forthwith a special committee to act in each case and report on each subject; the Board of Direction to report its action to the Society at its next regular meeting.

ARTICLE VII.—Nomination and Election of Officers.

1.—The Board of Direction shall, from time to time, divide the territory occupied by the membership into seven geographical districts, to be designated by numbers. District No. 1 shall be the territory within fifty miles of the Post Office in the City of New York. Each of the other six districts shall be, as nearly as practicable, contiguous territory; each shall contain, as nearly as practicable, an equal number of members, and they shall be designated as Districts Nos. 2, 3, 4, 5, 6 and 7. The Board shall announce such division to the Society on or before the first day of May in each year.

2.—At the Annual Meeting of each year, seven Corporate Members, not officers of the Society, one from each of the geographical districts, shall be appointed by the meeting to serve for two years; who, with the five living last Past-Presidents of the Society, shall be a committee to nominate officers for the Society.

The Board of Direction may prescribe the mode of procedure for appointing this Committee, and fill any vacancies occurring.

The Committee so appointed shall meet at the Annual Convention of the Society, and nominate candidates to fill the offices, named in Article V, so as to provide, with the officers holding over, a Vice-President and six Directors residing in District No. 1, and twelve Directors divided equally, with regard to number and residence, among the remaining districts, Nos. 2, 3, 4, 5, 6 and 7.

A list of nominees for the offices to be filled at the next Annual Election shall be presented by the Committee to the Board of Direction within ten days after the nominees have been selected.

3.—Directly after the first of October the aforesaid list of nominees shall be mailed to every Corporate Member whose address is known, provided that if any person shall be found by the Board of Direction to be ineligible for the office for which he is nominated, or should a nominee decline such nomination, his name shall not be sent out, but the Board shall substitute another name therefor. The Board shall also fill any vacancies that may occur in this list of nominees up to the time the ballots are sent out. Vacancies must be so filled as to preserve the geographical distribution of officers prescribed in Section 2 of this article.

4.—At any time before the first day of December, any ten or more Corporate Members may send to the Secretary additional nominations, signed by such members; but nominations so made must comply with Section 2 of this article, regarding the distribution of nominees among the several districts.

5.—At least thirty days before the Annual Meeting, there shall be mailed to every Corporate Member whose address is known a letter-ballot with envelopes for voting. This ballot shall include all the nominations made in accordance with this article. The names and residences of the nominees, their grades of membership, and, in the case of nominees for Directors, the number of the district in which they reside, shall be given. The names of the nominees for any one office shall be arranged alphabetically without distinguishing marks of any kind other than the designations named herein.

Voters may erase names from the printed ballot-list and may substitute the name or names of any other person or persons eligible for any office. But the number of names for each office on the ballot voted must not exceed the number to be elected at that time to such office. and the vote must be for the proper number of officers resident in each of the seven districts. Ballots not complying with these provisions shall be rejected.

Directions in accordance with these provisions shall be issued with the ballots.

6.—Ballots may be sent by mail to the Secretary, or may be presented to him at the Society House. They must be enclosed in two sealed envelopes, and the outer envelope shall be endorsed by the voter's signature.

The Secretary shall make from the signatures on the outer envelopes a list of the voters from whom ballots are received, which list shall be open to inspection by all Corporate Members. A voter may withdraw his ballot, and may substitute another, at any time before the polls close.

7.—The polls shall be closed at 12 o'clock noon on the first day of the Annual Meeting, and the ballots shall be canvassed publicly by tellers, who shall be appointed by the presiding officer.

The persons of each district who shall receive the highest number of votes for the office for which they are candidates shall be declared elected.

In case of a tie between two or more candidates for the same office, the Annual Meeting shall elect the officer from among the candidates so tied.

The presiding officer shall announce to the meeting the names of the officers elected, in accordance with this section.

ARTICLE VIII.—Meetings.

1.—A Convention of the Society for the reading and discussion of professional papers and for social intercourse shall be held annually at such time and place as the Society may determine.

2.—There shall be two general Business Meetings of the Society each year; the Annual Meeting, which shall be held at the offices of the Society on the third Wednesday in January, and at which the annual reports for the year ending December 31st previous shall be presented, and the ballot for officers canvassed; and a Business Meeting during the Annual Convention, which shall be held at a time and place to be determined by the Board of Direction.

At these meetings thirty Corporate Members shall constitute a quorum.

3.—Business Meetings shall be held monthly on the first Wednesday of each month, except during the months of July and August. At these meetings thirty Corporate Members shall constitute a quorum.

4.—In addition to the Annual Meeting and the Annual Convention meetings for the reading and discussion of papers shall be held as ordered by the Board of Direction.

5.—Special meetings may be called by the Board of Direction, and shall be so called on the request of thirty Corporate Members, which request shall state the purpose of such meeting. The call for such meetings shall be issued ten days in advance, and shall state the purpose thereof, and no other business shall be taken up at such meeting. At these meetings thirty Corporate Members shall constitute a quorum.

6.—The Society may adopt, from time to time, rules for the order of business at its meetings.

7.—Meetings of the Board of Direction shall be held at the time of the Annual Meeting and of the Annual Convention, at which meeting nine members shall constitute a quorum; and at such other times as the Board may determine, at which five members shall constitute a quorum.

ARTICLE IX.—Amendments.

1.—Proposed amendments to this Constitution must be reduced to writing and signed by not less than five Corporate Members, and be submitted and acted upon as follows:

2.—Amendments presented to the Secretary on or before the first Wednesday in November shall be sent by letter to the several Corporate Members of the Society at least twenty-five days previous to the Annual Meeting. Such amendments shall be in order for discussion at such Annual Meeting, and may be amended in any manner pertinent to the original amendments by a majority vote of the Annual Meeting, and if so amended shall be voted upon by letter-ballot in form as amended by the Annual Meeting; if not so amended, they shall be voted upon by letter-ballot as submitted. The vote to be counted at the first regular meeting in March.

3.—Amendments presented to the Secretary not less than sixty days previous to the date of the Annual Convention shall be sent by letter to the several Corporate Members of the Society at least twenty-five days previous to the Annual Convention. Said amendments shall be in order for discussion at the Business Meeting during such Annual Convention, and may be amended in any manner pertinent to the original amendments by a majority vote of the Business Meeting during the Annual Convention, and, if so amended, shall be voted upon by letter-ballot in form as amended by said Business Meeting; if not so amended, they shall be voted upon by letter-ballot as submitted. The vote to be counted at the first regular meeting in October.

4.—If, after discussion of a proposed amendment, at either of the general meetings of the Society, the meeting shall so decide by a majority vote, it may refer the amendment to a Committee for further consideration, which Committee shall report at the next general meeting, whereupon the amendment shall be voted upon as hereinbefore provided.

5.—An affirmative vote of two-thirds of all ballots cast shall be necessary to the adoption of any amendment.

Amendments so adopted shall take effect thirty days after their adoption, provided that the officers of the Society, at the time any amendment may be adopted, shall continue in office until the next Annual Election.

GENERAL INFORMATION

MEETINGS.—Regular meetings are held at the House of the Society, No. 220 West Fifty-seventh Street, New York, on the first and third Wednesdays of each month, at 8.30 P. M., except during the summer. The Annual Meeting is held on the third Wednesday in January. A Convention is held annually, at a time and place determined each year by the Society.

The House and Library of the Society are open from 9 A. M. to 10 P. M. every day, except Sundays, Fourth of July, Thanksgiving Day and Christmas Day.

PUBLICATIONS.—The Society issues two publications, *Proceedings* and *Transactions,* which are furnished without extra charge to the entire membership.

Proceedings are issued on the fourth Wednesday of each month except June and July (10 numbers per annum). Each number contains minutes of meetings, Society announcements, a classified list of articles in current engineering periodicals, a list of new books received in the Library, and other items connected with the affairs of the Society. Under the heading "Papers and Discussions" all Papers are here published in advance of their presentation at a Society meeting, as well as the discussion to which they subsequently give rise.

One volume of *Transactions* will be issued each year. In this volume each paper and its discussion, which has been previously published serially in *Proceedings,* is collated. In recent years there have been four volumes annually, and this single volume will contain approximately the same amount of printed matter (2 000 to 2 400 or more pages). It will be printed on the best quality of "India" or "Bible" paper. Members may order their volumes bound in Standard Half-Morocco or Cloth binding at a cost of $1.50 and 75 cents, respectively.

SUBSCRIPTION TO THE PUBLICATIONS.—To those not connected with the Society the annual subscription to *Proceedings,* if received on or before January first, is $8. The annual subscription to *Transactions,* if received on or before February first, is $12.

A discount of 25% is allowed to libraries, book dealers, etc., provided the subscription is received before the dates specified.

Single copies of *Proceedings* are $1. A special yearly subscription rate of $4.50 is also available to students in technical schools. There is an additional charge of 75 cents per annum to cover foreign postage.

GENERAL INFORMATION

Professional Papers.—All persons, whether members of the Society or not, are invited to send in papers and discussions on engineering subjects. All such communications are under the supervision of the Committee on Publications and are subject to proper editorial supervision. Under the Constitution, matter which may be readily found elsewhere, advocates personal interests, is carelessly prepared, controverts established facts, or is purely speculative or foreign to the purposes of the Society, is excluded.

All papers and discussions are published in *Proceedings:* Papers which are of such general interest and of such form as to be adapted for oral discussion are set down for presentation to a meeting of the Society, and oral as well as written discussion is invited; those which by reason of their technical nature cannot readily be discussed orally are not presented at any meeting, but written communications in discussion of them are published both in *Proceedings* and subsequently with the paper in *Transactions.*

All papers, on their acceptance by the Committee on Publications, become the property of the Society.

Additions to Library.—It is desirable that copies of books on engineering subjects, and of reports of municipal, railway, canal, water supply and all other public works, be added to the Library. Members of the Society, and all who feel an interest in the proper maintenance of a technical reference library, are asked to donate engineering books or reports.

Admission to Membership.—The requirements for each of the grades of membership may be found on pages 5 and 6.

For blank forms and other information, address the Secretary, at the Society House.

Fees and Dues.	Resident.				Non-Resident.			
	Members.	Associate Members.	Associates.	Juniors.	Members.	Associate Members.	Associates.	Juniors.
Entrance Fee	$30.00	$25.00	$20.00	$10.00	$30.00	$25.00	$20.00	$10.00
Yearly Assessment	25.00	25.00	15.00	15.00	15.00	15.00	10.00	10.00
Total, payable upon Election	$55.00	$50.00	$35.00	$25.00	$45.00	$40.00	$30.00	$20.00

Fellowship fee, $250 in one payment for life.

Annual dues are payable in advance on the 1st day of January.

Members elected during the last half of the year pay only one-half of the amount of dues for that year.

GENERAL INFORMATION

COMPOUNDING DUES.—The annual dues of a Corporate Member may be compounded by a single payment of $250; of an Associate by a payment of $150. Should a compounding Associate be elected to Corporate Membership, an additional payment of $100 is necessary.

All compounding Corporate Members or Associates, who may be or hereafter become Resident, remain liable for the annual payment of the difference between the annual dues of Resident and Non-Resident Corporate Members or Associates; but any Corporate Member may at any time compound for the future payment of all annual dues of every nature and kind by the payment of $75 in addition to the $250 hereinbefore named; and any Associate may at any time compound for the future payment of all annual dues as Associate by the payment of $40 in addition to the $150 hereinbefore named.

Any person compounding his dues must have paid his entrance fee, all arrears of dues, and the annual dues for the current year, before the compounding sum can be accepted.

Persons compounding shall sign an agreement that they will be governed by the Constitution and Laws of the Society as they are now formed, or as they may be hereafter altered, amended or enlarged; and that in case of their ceasing to be connected with the Society from any cause whatever, the amount theretofore paid by them for compounding, and for entrance fees and annual dues, shall be the property of the Society.

CERTIFICATES OF MEMBERSHIP.—The prices, to cover cost of Certificates, are as follows:

Parchment	$2.25
Parchment Paper	1.25

Certificates are not issued to Juniors.

BADGE.—This is of gold and enameled (Blue for Corporate Members, and Maroon for Associates and Fellows), with the member's name and membership number engraved on the back, and is mounted either as an ordinary pin, a scarf pin, a watch charm, or a button. The price is $5. Badges can be secured only upon application to the Secretary. They are not issued to Juniors.

REMITTANCES.—All remittances should be made payable to the order of the American Society of Civil Engineers.

THE SEVEN GEOGRAPHICAL DISTRICTS INTO WHICH THE TERRITORY OCCUPIED BY THE MEMBERSHIP IS DIVIDED, UNDER ART. VII, SEC. 1, OF THE CONSTITUTION

District No. 1.—The territory within 50 miles of the Post Office in the City of New York.

District No. 2.—Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut (except as included in District No. 1), Alaska, Canada, Europe, and Africa.

District No. 3.—New York and New Jersey (except as included in District No. 1), Michigan, Wisconsin, and Minnesota.

District No. 4.—Pennsylvania, Delaware, Maryland, Ohio, and the District of Columbia.

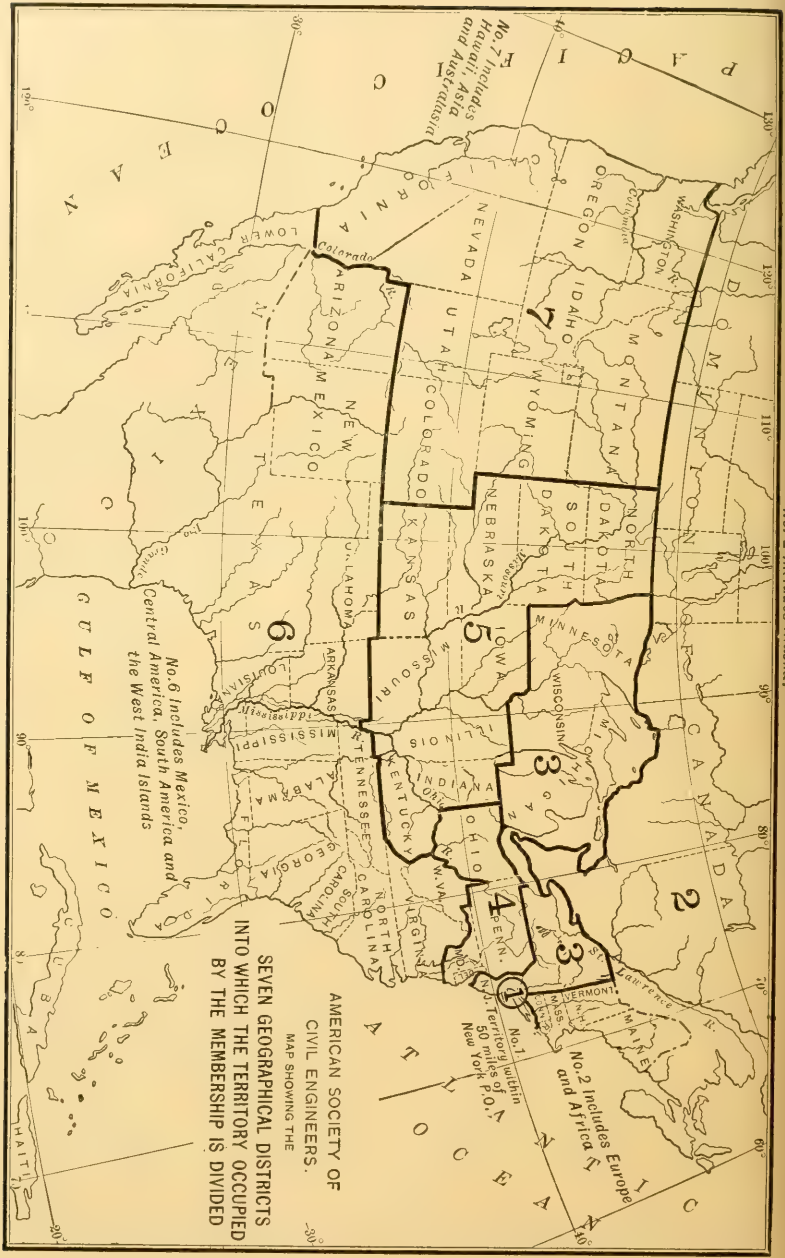
District No. 5.—North Dakota, South Dakota, Nebraska, Kansas, Iowa, Missouri, Illinois, Indiana, and Kentucky.

District No. 6.—Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas, New Mexico, Arizona, Mexico, the West India Islands, Central America, and South America.

District No. 7.—Montana, Wyoming, Colorado, Idaho, Utah, Washington, Oregon, California, Nevada, Hawaii, Asia, and Australasia.

These Districts are shown on the map on the next page.

GEOGRAPHICAL SUBDIVISIONS



AMERICAN SOCIETY OF CIVIL ENGINEERS.

MAP SHOWING THE

SEVEN GEOGRAPHICAL DISTRICTS INTO WHICH THE TERRITORY OCCUPIED BY THE MEMBERSHIP IS DIVIDED

No.1 Territory within 50 miles of New York P.O.

No.2 Includes Europe and Africa

No. 2 Includes Alaska.

No.6 Includes Mexico, Central America, South America and the West India Islands

No.7 Includes Hawaii, Asia and Australasia

LIST OF MEMBERS OF THE NOMINATING COMMITTEE.

		Term Expires.
District No. 1.—	O. E. Hovey	January, 1913
	Merritt H. Smith	“ 1914
District No. 2.—	F. H. Fay	January, 1913
	Harrison P. Eddy	“ 1914
District No. 3.—	Charles J. Tilden	January, 1913
	A. E. Kastl	“ 1914
District No. 4.—	Thomas H. Johnson	January, 1913
	J. F. Murray	“ 1914
District No. 5.—	E. E. Wall	January, 1913
	A. S. Baldwin	“ 1914
District No. 6.—	M. J. Caples	January, 1913
	J. F. Coleman	“ 1914
District No. 7.—	N. B. Kellogg	January, 1913
	R. H. Thomson	“ 1914
Past-Presidents—	George H. Benzenberg	January, 1913
	Charles Macdonald	“ 1914
	Onward Bates	“ 1915
	J. A. Bensel	“ 1916
	M. T. Endicott	“ 1917

RULES GOVERNING THE AWARD OF THE NORMAN MEDAL, THE THOMAS FITCH ROWLAND PRIZE, AND THE COLLINGWOOD PRIZE FOR JUNIORS

PRIZES.

There are at present three endowed prizes for papers published in the *Transactions* of the American Society of Civil Engineers. These prizes are awarded annually.

With the assent and the approval of the donors, by action of the Board of Direction, June 1st, 1897, the Society assumes the responsibility for the payment in perpetuity of the Norman Medal, Thomas Fitch Rowland Prize, and Collingwood Prize.

COMMITTEE ON PRIZES.

1. The Board of Direction shall appoint annually, not later than its regular meeting in June of each year, three Corporate Members of the Society, not members of the Board of Direction, who shall form a Committee to recommend the award of all prizes during the year.

2. The papers considered shall include all papers published in the *Transactions* during the year ending with the month of July.

3. The Committee on Prizes shall report its recommendation to the Board of Direction on or before December 31st, and the awards shall be made by the Board of Direction.

4. The announcement of the awards shall be made at the Annual Meeting.

5. The Secretary of the Society shall act as Secretary to the Committee on Prizes, but shall have no vote or voice in its deliberations.

CODE OF RULES.

The Norman Medal.—The Norman Medal was instituted and endowed in 1872 by the late George H. Norman, M. Am. Soc. C. E.

I. Competition for the Norman Medal of the American Society of Civil Engineers shall be restricted to members of the Society.

II. There shall be one gold medal awarded as hereinafter provided. The dies therefor shall be deposited with the Superintendent of the United States Mint at Philadelphia, in trust exclusively for the above purpose. Such medal shall be of a value of $60.

III. All original papers presented to the Society by members of any class, and published in the *Transactions* during the year for which the medal is awarded, shall be open to the award, provided that such papers shall not have been previously contributed in whole or in part to any other association, nor have appeared in print prior to their publication by the Society, nor have been published in the *Transactions* in any previous year.

IV. The medal shall be awarded to a paper which shall be judged worthy of special commendation for its merit as a contribution to engineering science.

The Thomas Fitch Rowland Prize.—The Thomas Fitch Rowland Prize was originally instituted by the Society at the Annual Meeting of 1882. It was endowed in 1884 by the late Thomas Fitch Rowland, Hon. M. Am. Soc. C. E. Its award is not restricted to members of the Society.

I. The prize shall consist of $60 in cash, with an engraved certificate signed by the President and Secretary of the Society.

II. In the award of this prize preference shall be given to papers describing in detail accomplished works of construction, their cost, and errors in design and execution.

The Collingwood Prize for Juniors.—The Collingwood Prize for Juniors was instituted and endowed in 1894 by the late Francis Collingwood, M. Am. Soc. C. E.

I. The competition for the prize shall be restricted to the Juniors of the Society.

II. The prize shall consist of $50 in cash, with an engraved certificate signed by the President and Secretary of the Society.

III. The prize shall be awarded to a paper describing an engineering work with which the writer has been directly connected, or it shall record investigations contributing to engineering knowledge, some essential part of which was made by the writer, and contain a rational digest of results. Any mathematical treatment must show immediate adaptability to professional practice. Accuracy of language and excellence of style will be factors in the award.

IV. These rules may be modified by the Board of Direction.

The awards of the Norman Medal, the Thomas Fitch Rowland Prize, and the Collingwood Prize for Juniors are indicated in the List of Members by the letters N., R., and C., respectively, prefixed to the name of each recipient.

MEDALS AND PRIZES

AWARDS OF THE NORMAN MEDAL

1874. J. James R. Croes, for paper "Memoir of the Construction of a Masonry Dam." Vol. III,* p. 337.

1875. Theodore G. Ellis, for paper "Description and Results of Hydraulic Experiments with Large Apertures, at Holyoke, Mass., in 1874." Vol. V,* p. 19.

1877. William W. Maclay, for paper "Notes and Experiments on the Use and Testing of Portland Cement." Vol. VI,* p. 311.

Book Prize awarded to Julius H. Striedinger, for paper "On Igniting Blasts by Means of Electricity." Vol. VII,* p. 1.

1879. Edward P. North, for paper "The Construction and Maintenance of Roads." Vol. VIII,* p. 95.

Book Prize awarded to Max E. Schmidt, for paper "Notes on the South Pass Jetties." Vol. VIII,* p. 189.

1880. Theodore Cooper, for paper "The Use of Steel for Bridges." Vol. VIII,* p. 263.

1881. L. L. Buck, for paper "The Re-Enforcement of the Anchorage and Renewal of the Suspended Superstructure of the Niagara Railroad Suspension Bridge." Vol. X,* p. 195.

1882. A. Fteley and F. P. Stearns, for paper "Description of Some Experiments on the Flow of Water Made During the Construction of Works for Conveying the Water of Sudbury River to Boston." Vol. XII,* p. 1.

1883. William P. Shinn, for papers "On the Increased Efficiency of Railways for the Transportation of Freight." Vol. XI,* p. 365; and "How can Railways be made more Efficient in the Transportation of Freight?" Vol. XII,* p. 189.

1884. James Christie, for paper "Experiments on the Strength of Wrought-Iron Struts." Vol. XIII,* p. 85.

1885. Eliot C. Clarke, for paper "Record of Tests of Cement Made for Boston Main Drainage Works." Vol. XIV,* p. 141.

1886. Edward Bates Dorsey, for paper "English and American Railroads Compared." Vol. XV,* p. 1.

1887. Desmond FitzGerald, for paper "Evaporation." Vol. XV,* p. 581.

1888. E. E. Russell Tratman, for paper "English Railroad Track." Vol. XVIII,* p. 217.

1889. Theodore Cooper, for paper "American Railroad Bridges." Vol. XXI,* p. 1.

1890. John R. Freeman, for paper "Experiments Relating to the Hydraulics of Fire Streams." Vol. XXI,* p. 303.

1891. John R. Freeman, for paper "The Nozzle as an Accurate Water Meter." Vol. XXIV,* p. 492.

1892. William Starling, for paper "Some Notes on the Holland Dikes." Vol. XXVI,* p. 559.

1893. Desmond FitzGerald, for paper "Rainfall, Flow of Streams, and Storage." Vol. XXVII,* p. 253.

1894. Alfred E. Hunt, for paper "A Proposed Method of Testing Structural Steel." Vol. XXX,* p. 181.

1895. William Ham. Hall, for paper "The Santa Ana Canal of the Bear Valley Irrigation Company." Vol. XXXIII,* p. 61.

1896. John E. Greiner, for paper "What is the Life of an Iron Railroad Bridge?" Vol. XXXIV,* p. 294.

1897. Julius Baier, for paper "Wind Pressures in the St. Louis Tornado, with Special Reference to the Necessity of Wind Bracing for High Buildings." Vol. XXXVII,* p. 221.

1898. B. F. Thomas, for paper "Movable Dams." Vol. XXXIX,* p. 431.

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* *Transactions*, Am. Soc. C. E.

1899. E. **Herbert Stone**, for paper "The Determination of the Safe Working Stress for Railway Bridges of Wrought Iron and Steel." Vol. XLI,* p. 467.
1900. **James A. Seddon**, for paper "River Hydraulics." Vol. XLIII,* p. 179.
1902. **Gardner S. Williams**, **Clarence W. Hubbell** and **George H. Fenkell**, for paper "Experiments at Detroit, Mich., on the Effect of Curvature upon the Flow of Water in Pipes." Vol. XLVII,* p. 1.
1904. **Emile Low**, for paper "The Breakwater at Buffalo, New York." Vol. LII,* p. 73.
1905. C. C. **Schneider**, for paper "The Structural Design of Buildings." Vol. LIV,* p. 371.
1906. **John S. Sewell**, for paper "The Economical Design of Reinforced Concrete Floor Systems for Fire-Resisting Structures." Vol. LVI,* p. 252.
1907. **Leonard M. Cox**, for paper "The Naval Floating Dock—Its Advantages, Design and Construction." Vol. LVIII,* p. 97.
1908. C. C. **Schneider**, for paper "Movable Bridges." Vol. LX,* p. 258.
1909. J. A. L. **Waddell**, for paper "Nickel Steel for Bridges." Vol. LXIII,* p. 101.
1910. C. E. **Grunsky**, for paper "The Sewer System of San Francisco, and a Solution of the Storm-Water Flow Problem." Vol. LXV,* p. 294.
1911. **George Gibbs**, for paper "The New York Tunnel Extension of the Pennsylvania Railroad: Station Construction, Road, Track, Yard Equipment, Electric Traction, and Locomotives." Vol. LXIX,* p. 226.

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* *Transactions*, Am. Soc. C. E.

AWARDS OF THE THOMAS FITCH ROWLAND PRIZE*

1883. G. Lindenthal, for paper "Rebuilding the Monongahela Bridge, at Pittsburgh, Pa." Vol. XII,† p. 353.
1884. Hamilton Smith, Jr., for paper "Water Power with High Pressures and Wrought-Iron Water Pipe." Vol. XIII,† p. 15.
1885. A. M. Wellington, for paper "Experiments with New Apparatus on Journal Friction at Low Velocities." Vol. XIII,† p. 409.
1886. Charles C. Schneider, for paper "The Cantilever Bridge at Niagara Falls." Vol. XIV,† p. 499.
1887. William Metcalf, for paper "Steel: Its Properties; Its Use in Structures and in Heavy Guns." Vol. XVI,† p. 283.
1888. Clemens Herschel, for paper "The Venturi Water Meter: An Instrument Making Use of a New Method of Gauging Water; Applicable to the Cases of Very Large Tubes, and of a Small Value Only, of the Liquid to be Gauged." Vol. XVII,† p. 228.
1889. James D. Schuyler, for paper "The Construction of the Sweetwater Dam." Vol. XIX,† p. 201.
1890. O. Chanute, John F. Wallace and William H. Breithaupt, for paper "The Sibley Bridge." Vol. XXI,† p. 97.
1891. William H. Burr, for paper "The River Spans of the Cincinnati and Covington Elevated Railway, Transfer and Bridge Company." Vol. XXIII,† p. 47.
1892. Samuel M. Rowe, Stillman W. Robinson and Henry H. Quimby, for paper "Red Rock Cantilever Bridge." Vol. XXV,† p. 662.
1893. William Murray Black, for paper "The Improvement of Harbors on the South Atlantic Coast of the United States." Vol. XXIX,† p. 223.
1894. David L. Barnes, for paper "Distinctive Features and Advantages of American Locomotive Practice." Vol. XXIX,† p. 385.
1895. William R. Hill, for paper "The Water-Works of Syracuse, N. Y." Vol. XXXIV,† p. 23.
1896. H. St. L. Coppée, for paper "Bank Revetment on the Lower Mississippi." Vol. XXXV,† p. 141.
1897. Arthur L. Adams, for paper "The Astoria (Oregon) City Water-Works." Vol. XXXVI,† p. 1.
1898. Henry Goldmark, for paper "The Power Plant, Pipe Line and Dam of the Pioneer Electric Power Company at Ogden, Utah." Vol. XXXVIII,† p. 246.
1899. R. S. Buck, for paper "The Niagara Railway Arch." Vol. XL,† p. 125.
1900. Allen Hazen, for paper "The Albany Water Filtration Plant." Vol. XLIII,† p. 244.
1901. L. G. Montony, for paper "The Ninety-Sixth Street Power Station of the Metropolitan Street Railway Company, of New York City." Vol. XLIV,† p. 119.
1902. William W. Harts, for paper "Description of Coos Bay, Oregon, and the Improvement of Its Entrance by the Government." Vol. XLVI,† p. 482.
1903. George W. Fuller, for paper "The Filtration Works of the East Jersey Water Company, at Little Falls, New Jersey." Vol. L,† p. 394.
1904. George Cecil Kenyon, for paper "Dock Improvements at Liverpool." Vol. LII,† p. 36.
1905. Charles L. Harrison and Silas H. Woodard, for paper "Lake Cheesman Dam and Reservoir." Vol. LIII,† p. 89.
1906. George B. Francis and W. F. Dennis, for paper "The Scranton Tunnel of the Lackawanna and Wyoming Valley Railroad." Vol. LVI,† p. 219.

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* This prize was known as the Rowland Prize from 1883 to 1896 and consisted of $50. Beginning with the award for 1897 it is to be known as the Thomas Fitch Rowland Prize and consists of $60, with an engraved certificate signed by the President and Secretary of the Society.

† *Transactions*, Am. Soc. C. E.

1907. **James D. Schuyler**, for paper "Recent Practice in Hydraulic-Fill Dam Construction." Vol. LVIII,† p. 196.

1908. **Edward E. Wall**, for paper "Water Purification at St. Louis, Mo." Vol. LX,† p. 170.

1909. **William J. Wilgus**, for paper "The Electrification of the Suburban Zone of the New York Central and Hudson River Railroad in the Vicinity of New York City." Vol. LXI,† p. 73.

1910. **John H. Gregory**, for paper "The Improved Water and Sewage Works of Columbus, Ohio." Vol. LXVII,† p. 206.

1911. **B. H. M. Hewett** and **W. L. Brown**, for paper "The New York Tunnel Extension of the Pennsylvania Railroad: The North River Tunnels." Vol. LXVIII,† p. 152.

AWARDS OF THE COLLINGWOOD PRIZE FOR JUNIORS

1895. **Morton L. Byers**, for paper "The Removal of the Channel Pier of the Cincinnati and Muskingum Valley Railway Bridge over the Scioto River." Vol. XXXI,† p. 361.

1896. **Herbert Waldo York**, for paper "The Twenty-Eighth Street Central Station of the United Electric Light and Power Company." Vol. XXXV,† p. 429.

1899. **Julius Kahn**, for paper "The Coal Hoists of the Calumet and Hecla Mining Company." Vol. XLI,† p. 269.

1900. **Robert P. Woods**, for paper "Street Grades and Cross-Sections in Asphalt and Cement." Vol. XLII,† p. 1.

1901. **F. A. Kummer**, for paper "A Proposed Method for the Preservation of Timber." Vol. XLV,† p. 181.

1903. **Isaac Harby**, for paper "The Footbridge for Building the Cables of the New East River Bridge." Vol. XLIX,† p. 165.

1904. **Herbert J. Wild**, for paper "The Substructure of Marsh River Bridge." Vol. LII,† p. 451.

1905. **E. P. Goodrich**, for paper "Lateral Earth Pressures and Related Phenomena." Vol. LIII,† p. 272.

1908. **D. W. Krellwitz**, for paper "Reinforced Concrete Towers." Vol. LX,† p. 160.

1909. **H. L. Wiley**, for paper "The Sinking of the Piers for the Grand Trunk Pacific Bridge at Fort William, Ontario, Canada." Vol. LXII,† p. 113.

1911. **A. Kempkey, Jr.**, for paper "A Concrete Water Tower." Vol. LXX,† p. 334.

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† *Transactions*, Am. Soc. C. E.

LOCATION AND DATE
OF
ANNUAL CONVENTIONS

Number.	Location.	Date	
First,	New York, N. Y.,	June,	1869
Second,	New York, N. Y.,	June,	1870
Third,	New York, N. Y.,	June,	1871
Fourth,	Chicago, Ill.,	June,	1872
Fifth,	Louisville, Ky.,	May,	1873
Sixth,	New York, N. Y.,	June,	1874
Seventh,	Pittsburgh, Pa.,	June,	1875
Eighth,	Philadelphia, Pa.,	June,	1876
Ninth,	New Orleans, La.,	April,	1877
Tenth,	Boston, Mass.,	June,	1878
Eleventh,	Cleveland, Ohio,	June,	1879
Twelfth,	St. Louis, Mo.,	May,	1880
Thirteenth,	Montreal, Que., Canada,	June,	1881
Fourteenth,	Washington, D. C.,	May,	1882
Fifteenth,	St. Paul and Minneapolis, Minn.,	June,	1883
Sixteenth,	Buffalo, N. Y.,	June,	1884
Seventeenth,	Deer Park, Md.,	June,	1885
Eighteenth,	Denver, Colo.,	July,	1886
Nineteenth,	Hotel Kaaterskill, N. Y.,	July,	1887
Twentieth,	Milwaukee, Wis.,	June,	1888
Twenty-first,	Seabright, N. J.,	June,	1889
Twenty-second,	Cresson, Pa.,	June,	1890
Twenty-third,	Lookout Mountain, Tenn.,	May,	1891
Twenty-fourth,	Old Point Comfort, Va.,	June,	1892
Twenty-fifth,	Chicago, Ill.,	July,	1893
Twenty-sixth,	Niagara Falls, N. Y.,	June,	1894
Twenty-seventh,	Hotel Pemberton, Hull, Mass.,	June,	1895
Twenty-eighth,	San Francisco, Cal.,	June,	1896
Twenty-ninth,	Quebec, Que., Canada.	June,	1897
Thirtieth,	Detroit, Mich.,	July,	1898
Thirty-first,	Cape May, N. J.,	June,	1899
Thirty-second,	London, England,	July,	1900
Thirty-third,	Niagara Falls, N. Y.,	June,	1901
Thirty-fourth,	Washington, D. C.,	May,	1902
Thirty-fifth,	Asheville, N. C.,	June,	1903
Thirty-sixth,	St. Louis, Mo.,	October,	1904
Thirty-seventh,	Cleveland, Ohio,	June,	1905
Thirty-eighth,	Frontenac, Thousand Islands, N. Y.,	June,	1906
Thirty-ninth,	City of Mexico, Mexico,	July,	1907
Fortieth,	Denver, Colo.,	June,	1908
Forty-first,	Bretton Woods, N. H.,	July,	1909
Forty-second,	Chicago, Ill.,	June,	1910
Forty-third,	Chattanooga, Tenn.,	June,	1911

LIST OF MEMBERS

AUTHORIZED ABBREVIATIONS

HONORARY MEMBER	Hon. M. Am. Soc. C. E.
MEMBER	M. Am. Soc. C. E.
ASSOCIATE MEMBER	Assoc. M. Am. Soc. C. E.
ASSOCIATE	Assoc. Am. Soc. C. E.
JUNIOR	Jun. Am. Soc. C. E.
FELLOW	F. Am. Soc. C. E.

The Board of Direction requests the use of these abbreviations in all cases.

The awards of the Norman Medal, the Thomas Fitch Rowland Prize, and the Collingwood Prize for Juniors, are indicated in this list by the letters N., R., and C., respectively, prefixed to the name of each recipient.

It is particularly requested that every
change of address
be communicated immediately to:
The Secretary, American Society of Civil Engineers,
220 West Fifty-seventh Street,
New York, N. Y.

PAST-PRESIDENTS

James Laurie	Nov. 5, 1852, to Nov. 6, 1867.
James Pugh Kirkwood	Nov. 6, 1867, to Aug. 5, 1868.
William Jarvis McAlpine	Aug. 5, 1868, to Nov. 3, 1869.
Alfred Wingate Craven	Nov. 3, 1869, to Nov. 1, 1871.
Horatio Allen	Nov. 1, 1871, to Nov. 5, 1873.
Julius Walker Adams	Nov. 5, 1873, to Nov. 3, 1875.
George Sears Greene	Nov. 3, 1875, to Nov. 7, 1877.
Ellis Sylvester Chesbrough	Nov. 7, 1877, to Nov. 6, 1878.
William Milnor Roberts	Nov. 6, 1878, to Nov. 5, 1879.
Albert Fink	Nov. 5, 1879, to Nov. 3, 1880.
James Bicheno Francis	Nov. 3, 1880, to Jan. 18, 1882.
Ashbel Welch	Jan. 18, 1882, to Sept. 25, 1882.*
Charles Paine	Jan. 17, 1883, to Jan. 16, 1884.
DON JUAN WHITTEMORE	Jan. 16, 1884, to Jan. 21, 1885.
Frederic Graff	Jan. 21, 1885, to Jan. 20, 1886.
Henry Flad	Jan. 20, 1886, to Jan. 19, 1887.
William Ezra Worthen	Jan. 19, 1887, to Jan. 18, 1888.
THOMAS COLTRIN KEEFER	Jan. 18, 1888, to Jan. 16, 1889.
Max Joseph Becker	Jan. 16, 1889, to Jan. 15, 1890.
William Powell Shinn	Jan. 15, 1890, to Jan. 21, 1891.
Octave Chanute	Jan. 21, 1891, to Jan. 20, 1892.
MENDES COHEN	Jan. 20, 1892, to Jan. 18, 1893.
William Metcalf	Jan. 18, 1893, to Jan. 17, 1894.
William Price Craighill	Jan. 17, 1894, to Jan. 16, 1895.
George Shattuck Morison	Jan. 16, 1895, to Jan. 15, 1896.
Thomas Curtis Clarke	Jan. 15, 1896, to Jan. 20, 1897.
BENJAMIN MORGAN HARROD	Jan. 20, 1897, to Jan. 19, 1898.
Alphonse Fteley	Jan. 19, 1898, to Jan. 18, 1899.
DESMOND FITZGERALD	Jan. 18, 1899, to Jan. 17, 1900.
JOHN FINDLEY WALLACE	Jan. 17, 1900, to Jan. 16, 1901.
John James Robertson Croes	Jan. 16, 1901, to Jan. 15, 1902.
ROBERT MOORE	Jan. 15, 1902, to Jan. 21, 1903.
ALFRED NOBLE	Jan. 21, 1903, to Jan. 20, 1904.
Charles Hermany	Jan. 20, 1904, to Jan. 18, 1905.
CHARLES CONRAD SCHNEIDER	Jan. 18, 1905, to Jan. 17, 1906.
FREDERIC PIKE STEARNS	Jan. 17, 1906, to Jan. 16, 1907.
GEORGE HENRY BENZENBERG	Jan. 16, 1907, to Jan. 15, 1908.
CHARLES MACDONALD	Jan. 15, 1908, to Jan. 20, 1909.
ONWARD BATES	Jan. 20, 1909, to Jan. 19, 1910.
JOHN ANDERSON BENSEL	Jan. 19, 1910, to Jan. 18, 1911.
MORDECAI THOMAS ENDICOTT	Jan. 18, 1911, to Jan. 17, 1912.

In this list, the names of deceased Past-Presidents are printed in italics.

* Mr. Ashbel Welch died September 25, 1882, during his term of office as President.

BOARD OF DIRECTION,
1912

PRESIDENT

JOHN A. OCKERSON

VICE-PRESIDENTS

Term expires January, 1913

ALFRED P. BOLLER   CHARLES L. STROBEL

Term expires January, 1914

CHARLES S. CHURCHILL   CHARLES D. MARX

SECRETARY

CHARLES WARREN HUNT

TREASURER

JOSEPH M. KNAP

DIRECTORS

Term expires January, 1913

**WILLIAM E. BELKNAP, HORACE LOOMIS, GEORGE A. KIMBALL,
PERCIVAL ROBERTS, Jr., CHARLES F. LOWETH, ARTHUR DeWINT FOOTE.**

Term expires January, 1914

**GEORGE C. CLARKE, CHARLES W. STANIFORD, JONATHAN P. SNOW,
ROBERT RIDGWAY, LEONARD W. RUNDLETT, WILLIAM H. COURTENAY.**

Term expires January, 1915

**LINCOLN BUSH, T. KENNARD THOMSON, EMIL GERBER,
WILLIAM CAIN, E. C. LEWIS, W. A. CATTELL.**

PAST-PRESIDENTS

(Members of the Board)

**GEORGE H. BENZENBERG, CHARLES MACDONALD, ONWARD BATES,
JOHN A. BENSEL, MORDECAI T. ENDICOTT.**

ASSISTANT SECRETARY

THOMAS J. McMINN

STANDING COMMITTEES

The President is *ex-officio* a member of all committees

On Finance

LINCOLN BUSH

HORACE LOOMIS
CHARLES W. STANIFORD
GEORGE A. KIMBALL
PERCIVAL ROBERTS, JR.

On Publications

WILLIAM E. BELKNAP

ROBERT RIDGWAY
CHARLES S. CHURCHILL
CHARLES L. STROBEL
JONATHAN P. SNOW

On Library

ALFRED P. BOLLER

CHARLES D. MARX
EMIL GERBER
CHARLES F. LOWETH
CHARLES WARREN HUNT

SPECIAL COMMITTEES

On Concrete and Reinforced Concrete

JOSEPH R. WORCESTER

J. E. GREINER
W. K. HATT
OLAF HOFF
ROBERT W. LESLEY
EMIL SWENSSON
A. N. TALBOT

RICHARD L. HUMPHREY

On Engineering Education

DESMOND FITZGERALD
BENJAMIN M. HARROD
ONWARD BATES
D. W. MEAD

On Steel Columns and Struts

AUSTIN L. BOWMAN

ALFRED P. BOLLER
EMIL GERBER
CHARLES F. LOWETH
RALPH MODJESKI
FRANK C. OSBORN
GEORGE H. PEGRAM
LEWIS D. RIGHTS
GEORGE F. SWAIN
EMIL SWENSSON
JOSEPH R. WORCESTER

On Bituminous Materials for Road Construction

W. W. CROSBY
A. W. DEAN
H. K. BISHOP
A. H. BLANCHARD

On Valuation of Public Utilities

FREDERIC P. STEARNS

H. M. BYLLESBY
THOMAS H. JOHNSON
LEONARD METCALF
ALFRED NOBLE
WILLIAM G. RAYMOND
JONATHAN P. SNOW

CLASSIFIED LIST

HONORARY MEMBERS

[Hon. M. Am. Soc. C. E.]

	Date of Membership
FOX, *Sir* DOUGLAS. 56 Moorgate St., London, E. C., England. (*Cor. M., June 7, 1871*)	Mar. 5, 1901
FRITZ, JOHN. 155 Market St., Bethlehem, Pa. (*M., July 5, 1893*)	Sept. 5, 1899
GRAY, GEORGE EDWARD. Cons. Engr., 2945 Magnolia St., Glenwood Park, Berkeley, Cal. (*M., July 2, 1873*)	June 5, 1894
MACKENZIE, ALEXANDER. Retired Chf. of Engrs. and Maj.-Gen., U. S. A., The Birmingham, 2611 Adams Mill Rd., Washington, D. C. (*M., Feb. 2, 1887*)	May 12, 1905
MELVILLE, GEORGE WALLACE. Rear-Admiral, U. S. N. (*Retired*), 532 Walnut St. (Res., 620 North 18th St.), Philadelphia, Pa.	Dec. 20, 1899
MILLS, HIRAM FRANCIS. Engr. of Proprietors of Locks and Canals on Merrimac River, Lowell, Mass.	Nov. 30, 1909
WHITE, *Sir* WILLIAM HENRY. 8 Victoria St., Westminster, London, S. W., England	Dec. 16, 1904
WHITTEMORE, DON JUAN. (*Past-President*). Cons. Engr., C., M. & St. P. Ry., 222 Biddle St., Milwaukee, Wis. (*M., July 10, 1872*)	Jan. 6, 1911

Honorary Members, 8.

CORRESPONDING MEMBERS

GLEIM, CHARLES OTTO. Civ. and Cons. Engr., 184 Dorotheenstrasse, Hamburg, Germany	April 5, 1876
PONTZEN, ERNEST. 65 Rue de Monceau, Paris, France	Jan. 5, 1876

Corresponding Members, 2.

MEMBERS

[M. Am. Soc. C. E.]

	Date of Membership
Abbot, Frederic Vaughan. Col., Corps of Engrs., U. S. A., U. S. Engr. Office, 25 Pemberton Sq., Room 1017, Boston, Mass.	Dec. 3, 1884
Abbot, Frederick William. Dongan Hills, N. Y. *(Assoc. M., Oct. 7, 1891)*	April 1, 1896
Abbott, Edward Lorenzo. 71 Broadway, New York City. *(Jun., Sept. 1, 1886; Assoc., April 30, 1895)*	Mar. 6, 1906
Abbott, Elizur Tavarro. Gen. Mgr., Klamath Lake R. R., Pokegama, Ore.	Oct. 7, 1908
Abbott, Fred Walter. 1328 Chestnut St., Philadelphia, Pa.	Sept. 7, 1904
Ackerman, John Walter. Chf. Engr. and Supt., Auburn Municipal Water-Works, Auburn, N. Y. *(Assoc. M., Sept. 6, 1905)*	Jan. 7, 1908
Adam, Robert. F. v. Lister & Co., Ltd., Dashwood House, 9 New Broad St., London, E. C., England	May 2, 1900
R. Adams, Arthur Lincoln. Cons. Hydr. Engr., Balboa Bldg., San Francisco, Cal.	Oct. 2, 1895
Adams, Edwin Griggs, Jr. Waverly, N. Y. *(Assoc. M., Jan. 1, 1896)*	Jan. 31, 1905
Adams, Frederick. S. Pearson & Son, Esquina Panuco y Sena, City of Mexico, D. F., Mexico	July 9, 1906
Adams, Henry Sewall. 108 Ames Bldg., Boston, Mass.	June 6, 1906
Affelder, Louis Jacob. Asst. Div. Contr. Mgr., Am. Bridge Co. of N. Y., Frick Bldg., Pittsburgh, Pa. *(Jun., Feb. 4, 1896; Assoc. M., June 5, 1901)*	June 5, 1906
Africa, James Murray. Cons. Engr.; City Engr., Huntingdon, Pa.	Sept. 2, 1896
Ahern, Jeremiah. Dixon, Cal.	May 4, 1904
Aiken, William Augustin. Vice-Pres., Henry S. Spackman Eng. Co., 42 North 16th St., Philadelphia, Pa.	Oct. 2, 1889
Aims, Walton Irving. 45 Broadway, New York City	May 4, 1904
Alber, Hermann. R. F. D. No. 394, Inglewood, Cal.	Dec. 6, 1905
Albertson, Charles. 529 Market St., Bangor, Pa. *(Jun., Oct. 1, 1895; Assoc. M., Mar. 1, 1899)*	Oct. 7, 1903
Alden, Charles Ames. Chf. Engr., F. and S. Dept., Penn. Steel Co., Steelton, Pa. *(Assoc. M., May 4, 1898)*	Sept. 6, 1904
Alden, Herbert Clarendon. Asst. Engr., Bureau of Sewers, 1518 Purdy St., Borough of Bronx, New York City. *(Assoc. M., Mar. 1, 1893)*	Feb. 2, 1909
Alden, John Ferris. Cons. Engr., Rochester, N. Y.	July 6, 1887
Alderman, Charles Aldo. Asst. Chf. Engr., Wyandotte Constr. Co., 1108 Grand Ave. Temple, Kansas City, Mo. *(Assoc M., April 6, 1898)*	April 2, 1902
Alderman, Clarence Edson. With Richardson, Barott & Richardson, Archts., 31 State St., Boston, Mass. *(Assoc. M., Sept. 6, 1905)*	Mar. 2, 1909
Aldrich, Truman Heminway. Room 1007, Brown Marx Bldg., Birmingham, Ala.	May 4, 1881
Alfred, Frank Hooker. Gen. Supt., C., H. & D. Ry., Carew Bldg., Cincinnati, Ohio	June 3, 1903
Alison, Thomas Henry. Care, Bergen Point Iron Works, Foot of West 5th St., Bayonne, N. J.	Oct. 7, 1908
Allan, Percy. Pres., Hunter Dist. Water Supply and Sewage Board; Dist. Engr., Newcastle, New South Wales, Australia. *(Assoc. M., April 1, 1896)*	Oct. 1, 1902
Allard, Thomas Throp. Chf. Engr. with Champion & Pascual, Contrs. and Engrs., 101 Obispo St., Havana, Cuba	Mar. 2, 1909
Allen, Andrews. Cons. and Contr. Engr. (Allen & Garcia), McCormick Bldg., Chicago, Ill.	Oct. 4, 1905
Allen, C. Frank. Prof. of R. R. Eng., Mass. Inst. Tech., Boston, Mass.	Feb. 6, 1878
Allen, Calvin Harlow. 1 West 72d St., New York City	Sept. 7, 1887
Allen, Charles Albert. Cons. Engr., Station A, Worcester, Mass.	June 4, 1879
Allen, Charles Kyes. Res. Engr. for Waddell & Harrington, 283 Oregon St., Portland, Ore.	Oct. 31, 1911
Allen, Charles Metcalf. Prof. of Hydr. Eng., Worcester Poly. Inst., Worcester, Mass. *(Assoc. M., June 1, 1904)*	April 4, 1911
Allen, Chauncey Loomis. Vice-Pres. and Gen. Mgr., Syracuse Rap. Trans. Ry.; Utica & Mohawk Val. Ry.; Oneida Ry., Syracuse, N. Y.	Oct. 4, 1905

	Date of Membership
ALLEN, HENRY CLAYTON. City Engr., City Hall, Syracuse, N. Y. (*Assoc. M., July 1, 1891*)	Jan. 3, 1905
ALLEN, HERMON CHARLES. Cons. Engr., The Tannatt-Allen Eng. Co., 412 Empire State Bldg., Spokane, Wash.	May 2, 1911
ALLEN, JAMES PIERSON. Asst. Engr., U. S. Engr. Office, 8 Ladson St., Charleston, S. C. (*Jun., Mar. 5, 1879*)	June 4, 1884
ALLEN, KENNETH. Engr., Met. Sewerage Comm. of New York, 17 Battery Pl., New York City	May 2, 1888
ALLEN, WALTER HINDS. Civ. Engr., U. S. N., Bureau of Yards and Docks, Navy Dept., Washington, D. C. (*Jun., May 1, 1900; Assoc. M., Nov. 4, 1903*)	Feb. 4, 1908
ALLEN, WILLIAM ANDREW. Care, Am. Smelting & Refining Co., East Helena, Mont. (*Assoc. M., Feb. 6, 1901*)	Sept. 6, 1904
ALLEN, WILLIAM BULLARD. Mgr., Land Dept., Tennessee Coal, Iron & R. R. Co., 1314 Wancoma Ave., Birmingham, Ala.	Feb. 3, 1904
ALLIN, THOMAS DAVID. 203 Kendall Bldg., Pasadena, Cal.	Jan. 3, 1906
ALMIRALL, RAYMOND FRANCIS. Archt., 185 Madison Ave., New York City.	Oct. 5, 1904
ALVORD, JOHN WATSON. Hydr. and San. Engr., 1417 Hartford Bldg., Chicago, Ill.	Jan. 4, 1893
AMBLER, JOHN NICHOLAS. Special Engr., City of Winston; Civ. and Hydr. Engr., Room 309, Masonic Temple, Winston-Salem, N. C.	May 6, 1908
AMBURSEN, NILS FREDERICK. Vice-Pres. and Chf. Engr., Ambursen Hydr. Constr. Co., Boston, Mass.	Jan. 8, 1908
AMWEG, FREDERICK JAMES. Advisory Engr. and Mgr. of Bldg. Operations, 700 Marston Bldg., San Francisco, Cal.	Mar. 7, 1888
ANDERSEN, CHRISTIAN. 251 Twelfth St., Portland, Ore.	Jan. 2, 1901
ANDERSON, DAVID GUY. Div. Engr., Penn. State Highway Dept. (Res., 4032 Walnut St.), Philadelphia, Pa. (*Assoc. M., Oct. 4, 1899*)	May 3, 1910
ANDERSON, GEORGE GRAY. Cons. Engr., 1232 First National Bank Bldg., Denver, Colo.	Feb. 7, 1906
ANDERSON, JOSHUA THOMAS NOBLE. Springbank, Narbethong, Victoria, Australia	Nov. 7, 1906
ANDERSON, WILLIAM POPE. Pres. and Chf. Engr., The Ferro-Concrete Const. Co., Richmond and Harriet Sts., Cincinnati, Ohio	April 6, 1909
ANDREWS, DANIEL MARSHALL. U. S. Asst. Engr., Room 401, West Bldg., Rome, Ga.	Mar. 2, 1892
ANDREWS, DAVID HERBERT. Pres., The Boston Bridge Works, Inc., 38 Lake Ave., Newton Center, Mass.	Sept. 2, 1885
ANDREWS, HIRAM BERTRAND. 166 Devonshire St., Boston, Mass.	Mar. 1, 1905
ANDREWS, HORACE. 125 Lancaster St., Albany, N. Y.	April 6, 1887
ANDROS, FREDERIC WILLIAM. Chf. Engr., Caribbean Constr. Co., Port-au-Prince, Haiti. (*Assoc. M., Feb. 1, 1899*)	Sept. 6, 1910
ANGIER, WALTER EUGENE. 1750 Monadnock Bldg., Chicago, Ill. (*Assoc. M., Sept. 7, 1892*)	Sept. 3, 1902
ANNAN, CHARLES LE ROY. Office Engr., Dept. of Public Works, St. Paul, Minn.	July 4, 1888
ANTHONY, CHARLES, JR. Gen. Mgr., Bahia Blanca Water-Works Co., Casilla de Correo 149, Bahia Blanca, Argentine Republic	Mar. 5, 1902
ANTHONY, CHARLES CHAPMAN. Asst. Signal Engr., P. R. R., Broad St. Station, Philadelphia, Pa.	Oct. 2, 1907
APPLETON, THOMAS. Supt. of Constr., U. S. Custom House, Room 144, Post Office Bldg., Boston, Mass.	April 4, 1883
APPLETON, THOMAS ALLEN. 311 Essex St., Beverly, Mass.	Jan. 2, 1912
ARANGO, RICARDO MANUEL. Chf. Engr. of the Republic of Panama, P. O. Box 140, Panama, Panama. (*Assoc. M., Sept. 2, 1896*)	Feb. 6, 1906
ARCHER, WILLIAM. Gen. Office, B. & O. S. W. R. R., Cincinnati, Ohio	Mar. 2, 1881
ARCHIBALD, PETER SUTHER. Cons. Engr., Moncton, N. B., Canada	Jan. 7, 1885
ARCHIBALD, WARREN MARTIN. Engr., M. of W., Houston Elec. Co.; Galveston Elec. Co.; Galveston-Houston Elec. Ry., Houston, Tex. (*Assoc. M., May 2, 1906*)	Jan. 3, 1911
ARENTZ, FREDERICK CHRISTIAN HOLBERG. Engr. and Contr., 627 Western Ave., Joliet, Ill. (*Assoc. M., May, 6, 1891*)	Oct. 3, 1900
AREY, RALPH JESSE. Pres., The Grand Canyon Elec. Light & Power Co., Williams, Ariz. (Res., 541 South Cummings St., Los Angeles, Cal.)	May 2, 1911
ARGOLLO, MIGUEL DE TEIVE E. Hotel Bayerischer-Hof, Munich, Germany.	Oct. 2, 1895
ARMSTRONG, ALEXANDER FLOYD. 1421 Chestnut St., Philadelphia, Pa. (*Jun., Oct. 7, 1902; Assoc. M., Nov. 1, 1905*)	Dec. 6, 1910
ARMSTRONG, JAMES WADSWORTH. Cons. Hydr Engr., Associate of George W. Fuller, 170 Broadway, New York City	Sept. 5, 1911
ARMSTRONG, WALTER ROOT. Supt., Mont. Div., Ore. Short Line R. R., Pocatello, Idaho	Oct. 4, 1905
ARMSTRONG, WILLIAM COULSON. Engr. of Bridges, C. & N. W. Ry., 226 West Jackson Blvd., Chicago, Ill.	June 1, 1909
ARNOLD, BION JOSEPH. 181 La Salle St., Chicago, Ill.	Mar. 1, 1905
ARNOLD, WILLIAM HARRY. 220 West 57th St., New York City	May 1, 1907
ARTHUR, HOWARD ELMER. 30 West 83d St., New York City	Nov. 8, 1909

	Date of Membership
Artingstall, Samuel George. 117 South Hamilton Ave., Chicago, Ill.	Oct. 6, 1886
Ash, Henry Clarke. Hydr. Engr., 15 Carlisle Ave., Hunters Park, Duluth, Minn.	Oct. 3, 1906
Ash, Louis Russell. City Engr., Kansas City, Mo. (*Assoc. M., Dec. 5, 1906*)	Sept. 6, 1910
Ashbaugh, Lewis Eugene. Hydr. Engr., J. G. White & Co., 510 Alaska Commercial Bldg., San Francisco, Cal. (*Assoc. M., Jan. 7, 1903*)	May 5, 1908
Ashbridge, Richard I Downing. East Downingtown, Pa. (*Assoc. M., Sept. 3, 1902*)	April 30, 1907
Ashmead, Frank Milligan. Asst. to Prin. Asst. Engr., B. & A. V. Div., P. R. R., 135 Richmond Ave., Buffalo, N. Y.	July 6, 1887
Ashmead, Percy Herbert. Cons. Engr., 43 Exchange Pl., New York City	Mar. 6, 1907
Ashton, William. Cons. Engr., 40 S St., Salt Lake City, Utah	May 6, 1908
Aspinwall, Thomas. 3 Hamilton Pl., Boston, Mass.	May 2, 1888
Asserson, Henry Raymond. 495 Sixth St., Brooklyn, N. Y.	Oct. 2, 1901
Atkinson, Timothy Ralph. State Engr. of North Dakota, Bismarck, N. Dak.	April 4, 1911
Atterbury, William Wallace. Fourth Vice-Pres., Penn. Lines East of Pittsburgh, Broad St. Station, Philadelphia, Pa.	Mar. 2, 1909
Atwater, Almon Byron. Asst. to Pres., G. T. W. Ry., Detroit, Mich.	May 5, 1886
Atwood, John Abiel. Chf. Engr., P. & L. E. R. R., Pittsburgh, Pa.	Jan. 3, 1900
Atwood, Thomas Clark. Div. Engr., Dept. of Water Supply, Gas and Electricity, 13 Park Row, New York City (Res., 207 Woodworth Ave., Yonkers, N. Y.) (*Assoc. M., April 3, 1907*)	Oct. 31, 1911
Atwood, William Greene. Chf. Engr., L. E. & W. R. R., Indianapolis, Ind. (*Assoc. M., July 10, 1907*)	Nov. 1, 1910
Auchincloss, William S. Atlantic Highlands, N. J.	Feb. 17, 1869
Auryansen, Frederick. Bridge Engr., L. I. R. R., 44 Union Hall St., Jamaica, N. Y. (*Jun., Oct. 5, 1897; Assoc. M., Dec. 3, 1902*)	April 6, 1909
Aus, Gunvald. Cons. Engr., 11 East 24th St., New York City	April 3, 1895
Austin, William Eugene. Archt., 46 West 24th St., New York City	Dec. 7, 1904
Averill, Frank Lloyd. Archt. and Engr. (Averill & Adams), 719 Union Trust Bldg., Washington, D. C. (*Assoc. M., Jan. 6, 1897*)	May 6, 1903
Avery, Frederick Hague. 1452 Winona Ave., Chicago, Ill.	May 31, 1910
Axtell, Decatur. First Vice-Pres., The C. & O. Ry. and Hocking Val. Ry., Richmond, Va.	Mar. 3, 1886
Aycrigg, William Anderson. Cons. Engr., 53 Prospect St., Stamford, Conn. (*Assoc. M., May 4, 1892*)	May 4, 1898
Ayres, Clarence Morton. Supt., Central Foundry Co., 1208 Queen City Ave., Tuscaloosa, Ala. (*Assoc. M., Oct. 2, 1901*)	Oct. 31, 1905
Ayres, Willis Edward. Cons. Engr., Randolph Bldg., Memphis, Tenn.	May 31, 1910
Babb, Cyrus Cates. Dist. Engr., U. S. Geological Survey, Care, Maine State Water Storage Comm., Augusta, Me. (*Jun., Feb. 2, 1892; Assoc. M., Feb. 3, 1897*)	Mar. 1, 1904
Babcock, Henry Nash. U. S. Asst. Engr., Army Bldg., 39 Whitehall St., New York City	Sept. 3, 1884
Bachert, Augustus Ellsworth. Gen. Supt., Rockhill Iron & Coal Co.; Chf. Engr., East Broad Top R. R., Tyrone, Blair Co., Pa.	June 3, 1908
Bacon, George Morgan. 159 Pierpont Ave., Salt Lake City, Utah. (*Assoc. M., Dec. 3, 1902*)	Dec. 5, 1905
Bacon, James Hayward. Ostega, Fla.	Jan. 3, 1900
Bacon, Theodore Hastings. Chf. Engr., Gilmore & Pittsburgh R. R. Co., Ltd., Armstead, Mont.	June 6, 1911
Bacot, William Sinclair. 234 Genesee St., Utica, N. Y.	Oct. 1, 1890
Badenhausen, John Phillips. Pres., The Eng. Constr. Co., 90 West St., New York City	Oct. 5, 1909
Baffrey, Charles Raymond. Pres., Hennebique Constr. Co., 1170 Broadway, New York City	Jan. 4, 1910
Bailey, William Melvin. Pres., The Concrete Eng. Co., Paddock Bldg., Boston (Res., Ridgewood Rd., Malden), Mass. (*Assoc. M., Sept. 5, 1900*)	Mar. 3, 1908
Baily, Thomas Chalkley James, Jr. Engr. of Bridges, Dist. of Columbia; Engr. of Harbor Committee, Washington, D. C.	Oct. 4, 1905
Baird, Howard Carter. Cons. Engr. (Boller, Hodge & Baird), 149 Broadway, New York City. (*Jun., June 6, 1893; Assoc. M., Oct. 5, 1898*)	Feb. 2, 1904
Baird, Samuel Pond. Pres., Standard Brick Co., Charleston, W. Va. (*Assoc. M., Mar. 1, 1899*)	Sept. 4, 1906
Bakenhus, Reuben Edwin. Civ. Engr., U. S. N., Bureau of Yards and Docks, Navy Dept., Washington, D. C.	Oct. 2, 1907
Baker, Charles Hinckley. Vice-Pres., Am. Cyanamid Co.; Vice-Pres., Muscle Shoals Hydro-Elec. Co., Mohegan Lake, N. Y.	June 4, 1902
Baker, Holland Williams. U. S. Asst. Engr., Care, Dubuque Boat & Boiler Works, Dubuque, Iowa	May 7, 1890

	Date of Membership
Baker, Ira Osborn. Prof. of Civ. Eng., Univ. of Illinois, 203 Engineering Bldg., Urbana, Ill.	May 3, 1893
Baker, Shirley. Mgr., Pipe Dept., Redwood Mfrs. Co., 916 Balboa Bldg., San Francisco, Cal. *(Jun., Sept. 11, 1900; Assoc. M., June 3, 1903)*	June 2, 1908
Baker, William Edgar. 105 West 40th St., New York City	June 1, 1898
Balch, William Hoyt. Director, Ayudante, Obras Publicas, Santo Domingo, Santo Domingo. *(Assoc. M., April 1, 1903)*	Dec. 3, 1907
Baldwin, Archibald Stuart. Chf. Engr., I. C. R. R., Chicago, Ill.	Dec. 6, 1905
Baldwin, Ernest Howard. Project Engr., U. S. Reclamation Service, Ellensburg, Wash. *(Assoc. M., May 4, 1898)*	Oct. 3, 1905
Baldwin, Fred Hixon. Supt., Bergenport Chemical Works, Bayonne, N. J.	Nov. 5, 1884
Baldwin, George Porter. Care, Gen. Elec. Co., Park Bldg., Pittsburgh, Pa.	Feb. 5, 1908
Baldwin, Thomas Williams. Weston Rd., Wellesley, Mass.	April 2, 1884
Baldwin, Ward. Cons. Engr., 807 Commercial Tribune Bldg., Cincinnati, Ohio. *(Jun., Mar. 2, 1881)*	Oct. 2, 1889
Baldwin, William Henry. Warburton Bldg., Yonkers, N. Y.	June 6, 1888
Baldwin, William James. Cons. Heating and Ventilating Engr., World Bldg., New York City	Sept. 5, 1888
Ball, Charles Backus. Chf. San. Insp., Dept. of Health, 215 Madison St. (Res., 1951 Sunnyside Ave.), Chicago, Ill.	Oct. 1, 1890
Ballard, Robert. 35 Wood Lane, Shepherd's Bush, London, W., England.	Sept. 1, 1880
Ballinger, Walter Francis. Archt. and Engr. (Ballinger & Perrot), 1211 Arch St., Philadelphia, Pa.	Feb. 7, 1906
Bamford, William Brokaw. Archt. and Cons. Engr., Trenton (Res., 614 Tenth Ave., Belmar), N. J. *(Jun., June 2, 1903; Assoc. M., Oct. 5, 1904)*	May 31, 1910
Banks, Hugh Cunningham. Waterloo, S. C.	June 6, 1911
Barber, William Davis. Asst. Engr., Bureau of Eng., Dept. of Public Works, Chicago, Ill. *(Assoc. M., Sept. 1, 1897)*	Jan. 8, 1902
Barbour, Frank Alexander. Cons. Hydr. and San. Engr., 1120 Tremont Bldg., Boston, Mass.	Sept. 5, 1900
Barcroft, Frederick Thomas. Cons. Engr. and Archt., Suite 1728 Ford Bldg., Detroit, Mich.	Sept. 3, 1902
Bard, George Parker. New York Mgr., The Petroleum Iron Works Co., 50 Church St., New York City	April 6, 1909
Bardol, Frank Valentine Erhard. Engr. and Contr., 400 D. S. Morgan Bldg., Buffalo, N. Y.	May 2, 1900
Barlow, John Quincy. Asst. Chf. Engr., Southern Pacific Co., 1120 Flood Bldg., San Francisco, Cal. *(Jun., April 7, 1886)*	July 4, 1888
Barnard, Edward Chester. Chf. Topographer, U. S. and Canada Boundary Survey, Care, Coast and Geodetic Survey, Washington, D. C.	Dec. 3, 1902
Barnes, Edward Harding. Chf. Engr., Grand Rapids & Ind. Ry., Grand Rapids, Mich.	Dec. 5, 1906
Barnes, Mortimer Grant. Cons. Engr.; Member, Board, Cons. Engrs. for Impvt., New York State Canals, 388 Western Ave., Albany, N. Y. *(Assoc. M., Nov. 2, 1898)*	May 31, 1904
Barnes, Osgood Frost. Div. Engr., Erie R. R., Susquehanna, Pa.	June 30, 1910
Barnes, Thomas Howard. Civ. and Municipal Engr., United Fruit Co.; Res., 8 Rock Hill, West Medford, Mass.	Oct. 4, 1899
Barnes, William Thomas. With Metcalf & Eddy, Engr. in Chg., Chicago Office, 1824 Harris Trust Bldg., Chicago, Ill. *(Assoc. M., Sept. 7, 1898)*	Oct. 3, 1911
Barnett, John William. City Engr., Athens, Ga.	Jan. 4, 1905
Barnett, Robert Crary. Cons. Engr., 510 Kansas City Life Bldg., Kansas City, Mo. *(Assoc. M., Dec. 5, 1900)*	Jan. 3, 1911
Barr, Joseph Carroll. Contr. Engr., Joplin, Mo. *(Assoc. M., Jan. 4, 1899)*	Nov. 1, 1910
Barragan, Mariano Melerio. 3ª de las Artes, No. 42, City of Mexico, Mexico	Feb. 5, 1908
Barrally, Thomas Webster. Engr. and Contr. (Barrally & Ingersoll), 853 Powers Bldg., Rochester, N. Y.	Dec. 5, 1906
Barrows, Harold Kilbreth. Associate Prof. of Hydr. Eng., Mass. Inst. Tech.; Cons. Engr. (Barrows & Breed), 6 Beacon St., Boston, Mass. *(Assoc. M., Jan. 6, 1904)*	Mar. 31, 1908
Bartlett, Henry Emmett. Engr., Tracks and Terminals, Chicago Passenger Subways, 1449 East 66th Pl., Chicago, Ill.	June 30, 1911
Bascom, Harry Franklin. (Bascom & Sieger), 603 Allentown Bank Bldg., Allentown, Pa. *(Jun., Dec. 5, 1899; Assoc. M., Sept. 4, 1901)*	Mar. 2, 1909
Basinger, James Garnett. 52 Broadway, New York City *(Assoc. M., Oct. 3, 1900)*	April 30, 1907
Bass, Frederic Herbert. Director, Eng. Div., Minnesota State Board of Health; Prof. of Municipal Eng., Univ. of Minnesota, Minneapolis, Minn. *(Assoc. M., Nov. 6, 1907)*	Sept. 5, 1911

MEMBERS B

	Date of Membership
Bassel, Robert. Regierungs und Bau-Rat, Lützow Strasse, 112, Berlin, W., Germany	May 2, 1888
Bassett, Carroll Phillips. Treas., Commonwealth Water & Light Co., Summit, N. J.	Nov. 7, 1888
Bassett, George Barclay. Pres. and Gen. Mgr., Buffalo Meter Co., Buffalo, N. Y.	Mar. 1, 1893
Bassett, John Benjamin. U. S. Asst. Engr., U. S. Engr. Office, Rock Island, Ill.	Dec. 1, 1908
BATES, ONWARD. (*Past-President*). 332 South Michigan Ave., Chicago, Ill.	Jan. 4, 1882
Baucus, William I. North Adams, Mass.	Oct. 7, 1908
Bauer, Jacob Louis. 130 Broad St., Elizabeth, N. J. (*Assoc M., Feb. 5, 1896*)	June 1, 1909
Baum, George. 520 Warburton Ave., Yonkers, N. Y. (*Jun., Jan. 4, 1892; Assoc. M., April 5, 1899*)	Mar. 6, 1906
Baum, Harry William. Contr. Mgr., James Stewart & Co., First National Bank Bldg., Denver, Colo.	Oct. 4, 1910
Baxter, Frank Edwin. Vice-Pres., Baxter, Straw & Storrs Constr. Co., 1250 E. South Temple St., Salt Lake City, Utah	Oct. 2, 1901
Baxter, George Strong. Railroad and lumber business, 15 William St., New York City. (*Jun., May 12, 1875*)	May 3, 1876
Bayliss, John Yancey. Care, Madeira-Mamoré Ry., Caixa 304, Manãos, Brazil. (*Assoc. M., Sept. 2, 1903*)	Sept. 1, 1908
Bayliss, Rawlinson Tennant. 11 Cornhill, London, E. C., England	June 4, 1890
Beach, Lansing Hoskins. Lt.-Col., Corps of Engrs., U. S. A., Room M, Custom House, New Orleans, La.	June 7, 1905
Beach, Robert James. Pres., R. J. Beach Eng. Co., 32 Broadway, New York City	May 2, 1900
Beahan, Willard. First Asst. Engr., L. S. & M. S. Ry., Room 50, Lake Shore Bldg., Cleveland, Ohio	April 3, 1889
Beard, Edward James. 3838 McGee St., Kansas City, Mo.	Feb. 7, 1900
Beardsley, Arthur. Emeritus Prof. of Eng., Swarthmore Coll., Swarthmore, Pa. (*Assoc., Sept. 1, 1875*)	Sept. 2, 1891
Beardsley, James Wallace. Chf. Engr., Irrig. Service, Guayama, Porto Rico	Dec. 4, 1901
Beattie, Roy Hamilton. Engr. and Contr., 57 North Main St., Fall River, Mass.	Oct. 5, 1909
Beatty, Philip Asfordby. Water Dept., Baltimore, Md. (*Assoc. M., Nov. 6, 1907*)	May 4, 1909
Beckwith, Frank. Missoula, Mont.	Nov. 7, 1900
Bedford, Thomas Archibald. Div. Engr., California Highway Comm., Redding, Cal.	Sept. 6, 1910
Beeler, John Allen. Vice-Pres. and Gen. Mgr., The Denver City Tramway Co., 617 Majestic Bldg., Denver, Colo.	July 10, 1907
Behrend, Bernard Arthur. Cons. Engr., 200 Devonshire St., Boston, Mass.	Oct. 5, 1909
Belden, Harry Austin. Capital Traction Co., Washington, D. C.	Oct. 4, 1905
Belknap, John Mansfield. Office Engr., Chf. Engr.'s Office, L. I. R. R., Jamaica (Res., Manhasset), N. Y. (*Assoc. M., May 4, 1904*)	Mar. 31, 1908
BELKNAP, WILLIAM ETHELBERT. (*Director*). 294 West End Ave., New York City. (*Jun., Mar. 31, 1891; Assoc. M., Mar. 6, 1895*)	Dec. 1, 1897
Bell, Alonzo Clarence. Chf. Engr., Board of Commrs. of the Port of New Orleans, Suite 200, New Orleans Court Bldg., New Orleans, La.	Mar. 7, 1900
Bell, Andrew. Cons. Engr., Almonte, Ont., Canada	Sept. 5, 1883
Bell, Gilbert James. Div. Engr., A., T. & S. F. Ry., Marceline, Mo. (*Jun., Sept. 7, 1887*)	Oct. 6, 1897
Bell, James Richard. Hazeldene, Ightham, Kent, England	Sept. 2, 1896
Bellinger, Lyle Frederick. Civ. Engr., U. S. N., U. S. Navy Yard, Philadelphia, Pa.	Nov. 6, 1901
Bellows, Oscar Francis. Res. Engr., New York State Barge Canal, 43 Triangle Bldg., Rochester, N. Y. (*Assoc. M., Dec. 4, 1901*)	May 1, 1906
Bement, Robert Bunker Coleman. Cons. and Contr. Engr.; Pres., Robinson, Cary & Sands Co., St. Paul, Minn.	Sept. 7, 1887
Benedict, Herschel Albert. Mech. Engr., Public Service Ry., Newark, N. J.	Mar. 2, 1909
Bennett, Samuel Givens. City Engr., Oxnard, Cal.	Oct. 3, 1906
BENSEL, JOHN ANDERSON. (*Past-President*). State Engr., New York State, Albany, N. Y. (*Jun., Sept. 2, 1885*)	Mar. 4, 1891
Benson, Orville. Pequannock, N. J.	June 5, 1901
Bent, Cornelius Conway Felton. Vice-Pres., Staten Island Rap. Tran. Ry., 17 State St., New York City	May 1, 1889
Bentzon, Adrian Benoni. Civ. Engr. and Contr., Calle Corcovado 408 Altos, Lima, Peru. (*Assoc. M., Mar. 6, 1901*)	Sept. 4, 1906
BENZENBERG, GEORGE HENRY. (*Past-President*). Cons. Engr., 1310 Wells Bldg., Milwaukee, Wis.	May 2, 1883
Bergen, Van Brunt. Shore Road and 77th St., Brooklyn, N. Y.	June 17, 1868

	Date of Membership
Berle, Kort. Cons. Engr., 11 East 24th St., New York City. (*Assoc. M., Dec. 6, 1899*)	Nov. 4, 1903
Berquist, Axel Samuel Frederick. 1571 Forty-seventh St., Brooklyn, N. Y.	June 6, 1906
Berry, George. Asst. Engr., Bureau of Highways, Municipal Bldg., Brooklyn, N. Y.	May 3, 1905
Berry, John Bennington. Chf. Engr., C., R. I. & P. Ry., La Salle Station, Chicago, Ill.	May 4, 1909
Berry, Thomas. 1042 Locust Ave., Long Beach, Cal.	July 1, 1908
Bettes, Charles Robert. Chf. Engr., Queens County Water Co., Far Rockaway, N. Y. (*Jun., Oct. 1, 1890; Assoc. M., June 7, 1893*)	June 1, 1909
Betts, Fred Keeler. Div. Engr., Board of Water Supply for New York City, 293 Wall St., Kingston, N. Y.	May 4, 1898
Betts, Romeo Thompson. Asst. Engr., Dept., Docks and Ferries, Pier A, N. R., New York City. (*Assoc. M., Oct. 3, 1900*)	Feb. 2, 1909
Beugler, Edwin James. Civ. Engr., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City. (*Jun., June 19, 1891; Assoc. M., Feb. 1, 1899*)	Jan. 5, 1904
Biddle, John. Col., Corps of Engrs., U. S. A., Army War Coll., Washington, D. C.	July 4, 1894
Bienenfeld, Abel Morris. Cons. Engr., Wells-Fargo Bldg., San Francisco, Cal.	Feb. 6, 1907
Bienenfeld, Bernard. Cons. Engr., 621 Wells-Fargo Bldg., San Francisco, Cal.	May 6, 1903
Bigelow, Edward Manning. Pittsburgh, Pa.	Dec. 4, 1889
Billin, Charles Emery. 2632 Lake View Ave., Chicago, Ill. (*Jun., April 5, 1876*)	July 3, 1878
Billings, Asa White Kenney. Care, Pearson Eng. Corporation, Ltd., 25 Broad St., New York City. (*Assoc. M., Dec. 5, 1906*)	Sept. 1, 1908
Binckley, George Sidney. Cons. Engr., 1108 Union Trust Bldg., Los Angeles, Cal.	April 5, 1910
Binkley, George Holland. Care, The Arnold Co., 105 South La Salle St., Chicago, Ill.	Oct. 1, 1902
Bisbee, Fred Milton. Engr., Western Lines, A., T. & S. F. Ry., La Junta, Colo.	May 3, 1899
Bishop, Hubert Keeney. Chf. Engr., Hawaii Loan Fund Comm., Hilo, Hawaii.	Oct. 5, 1904
Bishop, William Israel. Pres., Bishop Constr. Co., Ltd., Eastern Townships Bank Bldg., Montreal, Que., Canada. (*Assoc. M., Feb. 6, 1901*).	Oct. 2, 1906
Bissell, Clinton Spencer. Asst. Engr., P. R. R., 60 Worthington St., Winfield Junction, N. Y.	May 6, 1908
Bissell, Frank Edward. Chf. Engr., Akron, Canton & Youngstown Ry., 517 Everett Bldg., Akron, Ohio. (*Jun., April 2, 1884*)	Sept. 2, 1891
Bissell, Hezekiah. Altadena, Cal.	Sept. 15, 1869
Bixby, William Herbert. Gen., Corps of Engrs., U. S. A., 735 Southern Bldg., Washington, D. C.	April 5, 1882
Black, Alexander Leslie. 323 Baronne St., New Orleans, La.	Dec. 4, 1907
R. Black, William Murray. Col., Corps of Engrs., U. S. A., U. S. Engr. Office, Room 710, Army Bldg., New York City	June 6, 1888
Blackford, Francis Webster. Civ. and Min. Engr., 86 East 8th Ave., Columbus, Ohio.	April 4, 1888
Blackwell, Francis Ogden. Cons. Engr., 49 Wall St., New York City.	Oct. 5, 1904
Blake, Carroll. Birmingham Mgr., Fred. A. Jones Bldg. Co., 1010 Empire Bldg., Birmingham, Ala. (*Assoc. M., May 3, 1905*)	May 5, 1908
Blakeley, George Henry. Structural Engr., Bethlehem Steel Co., 517 Seneca St., South Bethlehem, Pa. (*Jun., Dec. 4, 1889*)	Oct. 2, 1895
Blakeslee, Clarence. Civ. Engr. and Contr. (C. W. Blakeslee & Sons), 58 Waverly St. (Res., 598 George St.), New Haven, Conn.	June 4, 1895
Blanchard, Arthur Horace. Cons. Engr.; Prof. of Highway Eng., Columbia Univ., New York City. (*Jun., Jan. 2, 1900; Assoc. M., April 5, 1905*)	May 4, 1909
Blanchard, Murray. Engr., Northern Contr. Co., Tallulah Falls, Ga. (*Assoc. M., April 2, 1902*)	Dec. 6, 1910
Bland, George Pierrepont. 510 Harrison Bldg., Philadelphia, Pa. (*Jun., April 7, 1875*)	May 4, 1881
Bland, John Carlisle. Engr. of Bridges, Penn. Lines W. of Pitts., Room 1115, Union Station, Pittsburgh, Pa. (*Jun., May 12, 1875*)	June 4, 1879
Blauvelt, Louis David. Chf. Engr., Denver, N. W. & Pac. Ry., 403 Tramway Bldg., Denver, Colo.	May 6, 1908
Blickle, Herman Renner. Secy. and Chf. Engr., Fort Pitt Bridge Works, Pittsburgh, Pa.	Nov. 1, 1910
Blodgett, Albert Morrill. Pres., A. M. Blodgett Constr. Co., 217 Midland Bldg., Kansas City, Mo.	Sept. 7, 1904
Blodgett, John. Contr. Engr., Riverside Bridge Co., Martins Ferry, Ohio. (*Jun., Dec. 4, 1889; Assoc. M., Jan. 2, 1901*)	Nov. 1, 1910
Bloom, J George. Pres., Southern Ballast Co., Mill Creek, Okla.	July 9, 1906

	Date of Membership
Bloss, Richard Parkhurst. Mechanicsville, N. Y.	Jan. 6, 1904
Blossom, Francis (Sanderson & Porter), 52 William St., New York City.	Dec. 4, 1907
Blum, Louis Philip. Asst. Engr., The W. G. Wilkins Co., 204 Broadway, North Side, Pittsburgh, Pa.	May 31, 1910
Blunt, William Titcomb. Swanton, Ohio	Oct. 5, 1898
Boardman, Charles Slauson. Cons. Engr., (Conkling & Boardman), 798 Ellicott Sq., Buffalo, N. Y.	Mar. 2, 1909
Body, John Benjamin. 2^a Puente de Alvarado 53, City of Mexico, D. F., Mexico. (*Assoc. M., Oct. 2, 1895*)	May 2, 1900
Bogart, John. Cons. Engr., 141 Broadway, New York City	Feb. 17, 1869
Boggs, Edward Marshall. Cons. Engr.; Chf. Engr., Constr. and M. of W., Oakland Traction Co., San F., Oakland & San J. Con. Ry., Sacramento Short Line, East Shore & Suburban Ry., P. O. Box 496, Oakland, Cal.	June 6, 1900
Boggs, Frank Cranstoun. Capt., Corps of Engrs., U. S. A., Gen. Purchasing Office, Isthmian Canal Comm., Washington, D. C.	Nov. 8, 1909
Bogue, Virgil Gay. 15 William St., New York City	Sept. 15, 1869
BOLLER, ALFRED PANCOAST. (*Vice-President*). Cons. Engr. (Boller, Hodge & Baird), 149 Broadway, New York City	Dec. 4, 1867
Bolton, Channing Moore. Millwood, N. Y.	Jan. 4, 1888
Bolton, Reginald Pelham. Cons. Engr., 55 Liberty St., New York City.	Sept. 6, 1899
Bond, Edward Austin. 375 State St., Albany, N. Y.	Sept. 6, 1899
Bond, George Meade. Mech. Engr., 141 Washington St., Hartford, Conn.	Feb. 2, 1887
Bond, Paul Stanley. Zamboanga, Mindanao, Philippine Islands	Dec. 6, 1910
Bonnyman, Alexander. Chf. Engr. and Gen. Mgr., Atlanta, Birmingham & Atlantic R. R., A., B. & A. R. R. Bldg., Atlanta, Ga.	Nov. 4, 1908
Bontecou, Daniel. Cons. Engr., 406 Dwight Bldg., Kansas City, Mo.	Nov. 5, 1879
Bonzano, Adolphus. Pres., Bonzano Rail Joint Co., 331 South 18th St., Philadelphia, Pa.	Aug. 7, 1872
Bonzano, Maximilian Ferdinand. Care, Union League Club, Philadelphia, Pa.	Jan. 6, 1886
Booth, Arthur Allen. Civ. and Min. Engr., 1026 Twelfth Ave., Spokane, Wash.	June 30, 1910
Booth, George William. Chf. Engr., Committee on Fire Prevention, National Board of Fire Underwriters, 135 William St., New York City. (*Assoc. M., Sept. 7, 1904*)	Nov. 2, 1908
Booth, William Henry. 19 Chatsworth Rd., West Norwood, S. E., London, England	July 4, 1888
Boright, William Parsons. Chatham, N. Y. (*Jun., Jan. 2, 1894; Assoc. M., Mar. 1, 1899*)	Mar. 5, 1907
Bosler, Harry Sherman. Gen. Contr. (Bosler & Flynn), Chattanooga, Tenn.	Feb. 4, 1903
Bott, John B. Engr., P. R. R., Brownsville, Pa.	Oct. 1, 1890
Bowen, Oscar Sidney. Res. Engr., G. N. Ry., Spokane, Wash.	May 4, 1909
Bower, Charles Phillip. Pres. of C. P. Bower Constr. Co., Gen. Contrs., Bulletin Bldg., Philadelphia, Pa.	June 5, 1907
Bowers, George. 359 Westford St., Lowell, Mass.	Oct. 1, 1902
Bowie, Augustus Jesse. 102-A Bluff, Yokohama, Japan	Nov. 1, 1882
Bowker, Willard Lewis. Walpole, Mass.	June 3, 1903
Bowman, Austin Lord. Cons. Engr., 165 Broadway, Room 500, New York City. (*Assoc. M., Sept. 7, 1892*)	Dec. 1, 1897
Bowman, Charles Abel. Secy. and Treas., Morrison & Farrington, Inc., 514 Dillaye Bldg., Syracuse, N. Y.	Nov. 1, 1905
Bowser, Edmund Hamilton. Chf. Timber Insp., I. C. R. R., 203 Rogers Bldg., Memphis, Tenn.	June 1, 1904
Boyd, James Churchill. Cons. Engr., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City. (*Jun., Sept. 3, 1895; Assoc. M., May 1, 1901*)	Sept. 3, 1907
Boyd, William Charles. Asst. Engr., Pittsburgh Rys., 435 Sixth Ave., Pittsburgh, Pa.	Dec. 4, 1907
Boyden, Harry Chester. Res. Engr., Los Angeles County Highway Comm., San Fernando, Cal.	June 3, 1908
Boynton, George Herbert. Pres., Gen. Constr. Co., McManus Bldg., Davenport, Iowa	Sept. 3, 1884
Brace, James Henry. Secy. and Treas., Fraser, Brace & Co., Box 311, Shelburne Falls, Mass. (*Assoc. M., Jan. 2, 1901*)	Sept. 6, 1904
Brackenridge, John Crosbie. Cons. Engr., 95 Liberty St., New York City.	May 5, 1897
Brackenridge, William Algernon. Vice-Pres. and Gen. Mgr., Southern California Edison Co., Los Angeles, Cal.	June 2, 1886
Brackett, Dexter. Chf. Engr., Met. Water-Works, 1 Ashburton Pl., Boston, Mass.	June 6, 1888
Bradbury, Edward Gatling. Civ. and San. Engr., 605 New Hayden Bldg., Columbus, Ohio. (*Assoc. M., Nov. 7, 1906*)	Aug. 31, 1909
Bradford, William. Cons. Engr., 909 Empire Bldg., Pittsburgh, Pa.	Dec. 7, 1898
Bradley, Daniel Edward. Berlin, Conn.	May 1, 1895

		Date of Membership
	Bradley, Frank Edward. 491 Fifth Ave., New York City	Feb. 6, 1907
	Brady, Samuel Dunlap. Chf. Engr., Little Kanawha Syndicate Lines, Morgantown, W. Va	Sept. 7, 1904
	Brainard, Owen. Cons. Engr.; Chf. Engr., Carrere & Hastings, Archts., 225 Fifth Ave., New York City	Oct. 3, 1906
	Bramwell, George Washington. Cons. Engr., 335 Broadway, New York City	Mar. 1, 1893
	Branch, Ernest William. Civ. and San. Engr., 947 Tremont Bldg., Boston, Mass	Sept. 6, 1905
	Braxton, Jaquelin Marshall. U. S. Asst. Engr., U. S. Engr. Office, Jacksonville, Fla. *(Jun., Jan. 5, 1897; Assoc. M., May 3, 1899)*	Oct. 31, 1905
	Brazer, George Herbert. Cons. Engr. (J. R. Worcester & Co.), 79 Milk St., Boston, Mass. *(Assoc. M., Nov. 1, 1905)*	April 6, 1909
	Breckinridge, William Lewis. Engr., M. of W., C., B. & Q. R. R., 226 West Adams St., Chicago, Ill	Oct. 7, 1903
	Breed, Charles Blaney. Associate Prof. in Civ. Eng., Mass. Inst. Tech.; Cons. Engr. (Barrows & Breed), 6 Beacon St., Boston, Mass. *(Assoc. M., May 6, 1903)*	April 4, 1911
	Breed, Oliver Clark. Cons. Civ. and Hydr. Engr., Fulton, N. Y	Sept. 6, 1910
	Breen, John Edward. Prin. Asst. Engr., Bay Ridge Impvt., L. I. R. R., Church St., Richmond Hill, N. Y	May 1, 1907
R.	Breithaupt, William Henry. Cons. Engr. (Keating & Breithaupt), 82 King St., East, Toronto, Ont., Canada. *(Jun., June 4, 1884)*	July 6, 1887
	Bremner, George Hampton. Engr., Illinois Dist., C., B. & Q. R. R., 226 West Adams St., Chicago, Ill	Dec. 6, 1899
	Brendlinger, Peter Franklin. Civ. Engr. and Contr., 1009 Arcade Bldg., Philadelphia, Pa	Sept. 7, 1887
	Brenneke, William George. Cons. Civ. Engr. (Brenneke & Fay), 1009 Fullerton Bldg., St. Louis, Mo. *(Assoc. M., Mar. 5, 1902)*	Jan. 2, 1906
	Breuchaud, Jules. Pres., Underpinning & Foundation Co., 290 Broadway (Res., The Belnord, Broadway and 86th St.), New York City. *(Assoc., June 5, 1889)*	Oct. 5, 1898
	Brewer, Bertram. City Engr., Waltham, Mass	June 1, 1909
	Brewster, Henry Baum. Engr., H. S. Kerbaugh, Inc., Contrs., Fairport, N. Y. *(Assoc. M., Mar. 6, 1907)*	Mar. 2, 1909
	Briggs, Benjamin E. City Engr., City Hall, Erie, Pa	Nov. 4, 1908
	Briggs, Josiah Ackerman. Cons. Engr., 150 Nassau St., New York City.	Sept. 1, 1886
	Briggs, Waldo Clayton. Chf. Engr., Degnon Realty & Terminal Impvt. Co., Long Island City, N. Y	July 10, 1907
	Brinckerhoff, Alexander Gordon. Gen. Mgr., Johnson & Morris, 538 West 23d St., New York City	Nov. 3, 1886
	Brinsmade, Daniel Seymour. Pres., The Ousatonic Water Co., Derby, Conn	Feb. 1, 1888
	Britt, Dudley Digges. Civ. and Min. Engr., Clarksburg, W. Va	April 1, 1908
	Brohm, William Carl. Vice-Pres. and Gen. Mgr., Grainger & Co., Inc., Iron Works, Louisville, Ky	Feb. 1, 1905
	Brooks, Frederick. Secy., Assoc. Eng. Societies, 31 Milk St., Boston, Mass. *(Jun., June 7, 1876)*	Jan. 2, 1884
	Brooks, Walter Freeman. County Surv., Blue Earth County, Court House, Mankato, Minn	June 30, 1911
	Brosius, Albert Marshall. First Asst. Engr., Baltimore Sewerage Comm., American Bldg., Baltimore, Md	Mar. 1, 1910
	Brown, Baxter Lamont. 610 Merchants-Laclede Bldg., St. Louis, Mo	April 1, 1903
	Brown, Charles Carroll. Cons. Engr.; Editor, *Municipal Engineering Magazine*, 408 Commercial Club Bldg., Indianapolis, Ind	Oct. 2, 1895
	Brown, Charles Otto. Cons. Engr., 624 Madison Ave., New York City. *(Jun., Jan. 6, 1875)*	Nov. 7, 1877
	Brown, Earl Ivan. Maj., Corps of Engrs., U. S. A., U. S. Engr. Office, Galveston, Tex	Feb. 2, 1909
	Brown, Frank Dudly. City Engr., Shawnee, Okla	Oct. 4, 1910
	Brown, Le Grand. Pres. and Chf. Engr., Mokelumne River Power Co., 34 Ellis St., San Francisco, Cal	May 4, 1898
	Brown, Louis Livingston. Gen. Supt., The Foundation Co., 115 Broadway, New York City	May 3, 1905
	Brown, Maurice Fritchley. Chf. Engr., Boston Bridge Works, 47 Winter St., Boston, Mass. *(Assoc. M., Mar. 4, 1903)*	Feb. 28, 1905
	Brown, Norman Freed. 427 Atlantic Ave., Pittsburgh, Pa. *(Assoc. M., June 5, 1907)*	Nov. 30, 1909
	Brown, Paul Goodwin. Contr. Engr., 17 West 42d St., New York City	May 2, 1906
	Brown, Perry Fisher. 300 Park View Terrace, Oakland, Cal	June 3, 1908
	Brown, Ralph Henry. Chf. Engr., Eastern Bridge & Structural Co., Station A, Worcester, Mass	June 7, 1899
	Brown, Robert Calvin. Evergreen Ave., Plainfield, N. J	Dec. 5, 1906
	Brown, Stephen Pearson. Chf. Engr., The Tide Water Bldg. Co. and Thomas B. Bryson, 641 Fourth Ave., Brooklyn, N. Y. *(Assoc. M., Oct. 5, 1904)*	Nov. 1, 1910

MEMBERS B

	Date of Membership
Brown, Thomas Ellis. Cons. Engr., Otis Elevator Co., 17 Battery Pl., New York City. (*Jun., Nov. 3, 1880*)	April 2, 1884
Brown, Walter Henry. Constr. and Hydr. Engr., 698 Bush St., San Francisco, Cal	May 31, 1910
Brown, Wendell Phillips. Contr. Engr., King Bridge Co., Cleveland, Ohio. (*Assoc. M., Oct. 2, 1895*)	Mar. 5, 1902
Brown, William. Chairman and Managing Director, William Simons & Co., Ltd., 7 Whittingehame Gardens, Kelvinside, Glasgow, Scotland.	Oct. 3, 1911
Brown, William Gerrie. Cons. Engr., Clifton, Ore	Nov. 7, 1906
R. Brown, William Lowe. Engr. of Underground Lines, Oficina del Subterráneo, F. C. Oeste, Buenos Aires, Argentine Republic. (*Assoc. M., Sept. 6, 1905*)	Oct. 1, 1907
Brown, William Maxwell. Chf. Engr., Met. Sewerage Works, 1 Ashburton Pl., Boston, Mass	Feb. 5, 1896
Browne, George Hamilton. Hawkwood, Zion, Louisa Co., Va	Sept. 3, 1884
Browne, James Simpson. Div. Engr., N. Y., N. H. & H. R. R., 409 Union Station, Providence, R. I. (*Assoc. M., Oct 4, 1893*)	July 1, 1909
Browne, William Lyon. Chf. Engr., Bishop Constr. Co., Ltd., E. T. Bank Bldg., Montreal, Que., Canada	Jan. 31, 1911
Brownell, Ernest Henry. Civ. Engr., U. S. N., Navy Yard, Bremerton, Wash. (*Assoc. M., Jan. 1, 1896*)	Jan. 5, 1904
Browning, George Elliot. Chf. Engr., Cochin Govt., Rose Bank, Trichur, South India. (*Assoc. M., May 7, 1902*)	April 4, 1905
Brownlee, James Leeman. Cons. Engr., 314 Madison Ave., New York City	May 6, 1896
Bruce, Fred William. U. S. Asst. Engr., Jacksonville, Fla	April 4, 1900
Brumley, Daniel Joseph. Prin. Asst. Engr., I. C. R. R., 1 Park Row, Chicago, Ill	June 3, 1908
Bruner, Abraham. Care, N. & W. Ry., Roanoke, Va	Mar. 1, 1910
Brunner, John. Asst. Gen. Supt., North Works, Illinois Steel Co., 1319 Wabansia Ave., Chicago, Ill	Mar. 2, 1898
Bryan, Charles Walter. Chf. Engr., Am. Bridge Co., 30 Church St., New York City	June 3, 1903
Bryan, Fred Asdel. Gen. Mgr., Ind. & Mich. Elec. Co., 220 West Colfax Ave., South Bend, Ind	Dec. 1, 1908
Bryant, Byron Harkness. Chf. Engr., Mexico North Western Ry., Chihuahua, Chihuahua, Mexico	Sept. 6, 1910
Brydone-Jack, Ernest Edmund. Prof. of Civ. Eng., Univ. of Manitoba; Cons. Engr., Winnipeg, Man., Canada. (*Assoc. M., Oct. 4, 1899*)	Oct. 6, 1908
Bryson, Andrew. Pres., Brylgon Steel Casting Co., New Castle, Del	April 1, 1885
Buchanan, Edward Everett. Cons. Bridge Engr., Elmira, N. Y	Dec. 4, 1889
Buchholz, Carl Waldemar. Cons. Engr., Erie R. R., 50 Church St., New York City	Sept. 1, 1886
Buck, Henry Robinson. Cons. Engr. (Ford, Buck & Sheldon, Inc.), 60 Prospect St., Hartford, Conn. (*Jun., June 5, 1900; Assoc. M., Oct. 4, 1905*)	Feb. 4, 1908
R. Buck, Richard Sutton. (Sanderson & Porter), 52 William St., New York City. (*Assoc. M., April 5, 1893*)	Mar. 2, 1898
Buck, Waldo Emerson. Pres. and Treas., Worcester Mfrs. Mutual Insurance Co., 31 Institute Rd., Worcester, Mass	July 3, 1889
Budd, Robert Dunn. City Engr., Petersburg, Va	Oct. 4, 1910
Budge, Edward Barnard. Engr. in Chf., 1st Section, Chili State Rys., Chacabuco St., No. 13, Valparaiso, Chili	Nov. 6, 1901
Budge, Enrique. Hôtel des Champs Elysées, 3 rue Balzac, Paris, France.	Feb. 1, 1882
Buehler, Walter. Second Vice-Pres. and Cons. Engr., The Kettle River Co., 4300 Fremont Ave., South, Minneapolis, Minn. (*Assoc. M., Mar. 7, 1906*)	Jan. 4, 1910
Buel, Albert Wells. Cons. Engr., 15 William St., New York City	Sept. 5, 1911
Buel, Emott Davis. Engr. for John Monks & Sons, 82 Beaver St., New York City	June 30, 1910
Buffinton, Benjamin Thomas. 22 Bedford St., Fall River, Mass. (*Assoc. M., Sept. 7, 1904*)	Jan. 3, 1907
Bull, George Mairs. Cons. Engr. (Bull & Witham), Foster Bldg., Denver, Colo	Feb. 2, 1909
Bullock, William Dexter. Asst. Engr. in Chg., Bridges and Harbor, City Engr.'s Office, Providence, R. I. (*Jun., Sept. 5, 1887*)	July 4, 1888
Burbank, George Barker. 15 Wall St., New York City	July 4, 1888
Burden, James. Res. Engr., New York State Barge Canal, Oswego, N. Y. (*Assoc. M., Feb. 5, 1902*)	Jan. 5, 1904
Burdett, Frederick Anderson. Cons. Engr., 16 East 33d St., New York City. (*Jun., Feb. 2, 1897; Assoc. M., June 1, 1898*)	Oct. 7, 1903
Burdick, Charles Baker. Hydr. and San. Engr. (Alvord & Burdick), 1417 Hartford Bldg., Chicago, Ill. (*Assoc. M., Mar. 1, 1905*)	June 30, 1911
Burger, William Henry. Asst. Prof. of Civ. Eng., Coll. of Eng., Northwestern Univ., Box 174, Evanston, Ill	Nov. 1, 1910
Burgess, Alfred Samuel. Asst. Engr., New York Aqueduct Comm., 280 Broadway (Res., 1822 Anthony Ave.), New York City	Sept. 6, 1905

		Date of Membership
	Burgess, George Heckman. Chf. Engr., Delaware & Hudson Co., Albany, N. Y. *(Jun., Feb. 1, 1898; Assoc. M., June 3, 1903)*	July 1, 1909
	Burgess, Harry. Maj., Corps of Engrs., U. S. A., Custom House, Nashville, Tenn	Oct. 5, 1909
	Burgess, Philip. Hydr. and Chemical Engr. (Burgess & Long), 828 Cols. Savings and Trust Bldg., Columbus, Ohio. *(Assoc. M., Nov. 7, 1906)*	June 30, 1911
	Burke, Hubert Francis Daubeney. Director Gen. of Public Works, Dominican Republic, Santo Domingo, Santo Domingo	Feb. 1, 1910
	Burke, John Thomas. Caldwell, Idaho. *(Assoc. M., Nov. 1, 1905)*	Oct. 6, 1908
	Burke, Milo Darwin. Cons. Engr. (Burke & Venable), Room 706, Second National Bank Bldg., Cincinnati, Ohio	July 4, 1894
	Burley, Harry Benjamin. 586 Newton St., Chestnut Hill, Brookline, Mass	Mar. 4. 1908
	Burns, Clinton Sumner. Civ., Hydr. and San. Engr., 823 Scarritt Bldg., Kansas City, Mo. *(Assoc. M., Feb. 1, 1899)*	Jan. 3, 1905
	Burns, Edward Cook. 417 Spring St., Jamestown, N. Y	July 5, 1882
	Burpee, Moses. Chf. Engr., B. & A. R. R., Houlton, Me	Sept. 3, 1884
	Burr, Edward. Lt.-Col., Corps of Engrs., U. S. A., Office of Chf. Engr., U. S. A., Washington, D. C	May 6, 1891
R.	Burr, William Hubert. Cons. Engr.; Prof. of Civ. Eng., Columbia Univ., New York City. *(Jun., June 3, 1874; Assoc., May 5, 1880)*	Mar. 3, 1886
	Burrowes, Harry Gilbert. Res. Engr., Hudson & Manhattan R. R., 30 Church St., New York City. *(Jun., Sept. 2, 1902; Assoc. M., Feb. 3, 1904)*	July 1, 1909
	Burt, Henry Jackson. Chf. Engr., Holabird & Roche, 1618 Monadnock Bldg., Chicago (Res., 1045 Elmwood Ave., Wilmette), Ill	Mar. 1, 1905
	Burton, Alfred Edgar. Dean and Prof. of Topographical Eng., Mass. Inst. Tech., Boston, Mass	Sept. 4, 1901
	Bush, Edward Wallace. Chf. Engr., East Haddam and Haddam Bridge Comm., East Haddam (Res., Lyme), Conn. *(Assoc. M., April 5, 1899)*	April 30, 1907
	Bush, Harry Dean. Gen. Supt., Baltimore Warehouse, Carnegie Steel Co., Baltimore, Md	May 2, 1888
	BUSH, LINCOLN. *(Director)*. Cons. Engr., 1 Madison Ave., New York City.	Oct. 4, 1905
	Butcher, William Laramy. 2 Avon St., Cambridge, Mass. *(Assoc. M., May 4, 1904)*	Jan. 3, 1911
	Butler, Matthew Joseph. Second Vice-Pres. and Gen. Mgr., Dominion Iron & Steel Co. and Dominion Coal Co., Sydney, N. S., Canada	April 1, 1885
	Butterfield, Francis Eaves. Culiacan, Sinaloa, Mexico	Sept. 1, 1886
	Butts, Edward Pontany. Chf. Engr., Am. Writing Paper Co., Holyoke (Res., Springfield), Mass. *(Assoc. M., Feb. 2, 1898)*	Oct. 7, 1903
	Byam, Le Roy Henry. Secy. and Treas., The Elliot C. Brown Co., 27 William St., New York City	July 1, 1908
	Byers, Alexander Mosby Clayton. Supt., M. W., B. and B., Tehuantepec National Ry., Rincon Antonio, Oax., Mexico	Nov. 6, 1907
	Byers, Maxwell Cunningham. Chf. Engr., Operation, St. L. & S. F. R. R., Springfield, Mo	June 6, 1911
C.	Byers, Morton Lewis. Special Agt., Delaware & Hudson Co., 32 Nassau St., New York City (Res., 61 Harrison St., East Orange, N. J.). *(Jun., Jan. 2, 1890)*	Sept. 7, 1898
	Byllesby, Henry Manson. Pres., H. M. Byllesby & Co. (Inc.), Engrs., 206 South La Salle St., Chicago, Ill	June 1, 1887

	Cahill, Walter John. Chf. Engr. and Second Vice-Pres., Great Lakes Dredge & Dock Co., Chamber of Commerce (Res., 1030 E. 47th St.), Chicago, Ill	June 6, 1906
	CAIN, WILLIAM. *(Director)*. Prof. of Math., Univ. of North Carolina, Chapel Hill, N. C	Nov. 7, 1888
	Cairns, Robert Andrew. City Engr., Waterbury, Conn	Oct. 2, 1895
	Calderwood, Isaac Glidden. Massena, N. Y	June 1, 1909
	Caldwell, Charles Adolphus. 415 Fourth St., Macon, Ga	Sept. 5, 1911
	Caldwell, William Howell. Room 501, Curry Bldg., Tampa, Fla	May 4, 1909
	Callaghan, John. P. O. Box 610, Edmonton, Alta., Canada	Oct. 3, 1906
	Camp, Walter Mason. Chf. Editor, *Railway and Engineering Review*, 7740 Union Ave., Chicago, Ill	May 1, 1901
	Campbell, John Logan. Engr., M. of W., El Paso & Southwestern R. R., El Paso, Tex	May 1, 1901
	Campen, George Linden. Asst. City Engr., Omaha, Nebr	Oct. 5, 1909
	Campion, Horace Thomas. Pres., The Campion McClellan Co., 1218 Chestnut St., Philadelphia, Pa	July 1, 1909
	Canals, José Antonio. Civ. Engr. and Archt., 16 Tetuan St., San Juan, Porto Rico	May 3, 1905
	Canfield, Edward. Gen. Supt., N. Y., O. & W. Ry., Middletown, N. Y	Dec. 3, 1879
	Cannon, Madison Mott. Care, W. L. Miller, 19 Milk St., Boston, Mass	Jan. 2, 1907
	Cantine, Edward Ike. Engr. and Contr., 505 Railway Exchange, Portland, Ore	May 3, 1905

	Date of Membership
Caples, Martin Joseph. Fourth Vice-Pres., C. & O. and Hocking Val. Rys., Richmond, Va. *(Assoc. M., Nov. 4, 1891)*	Oct. 4, 1899
Cappelen, Frederick William. Chf. Engr. and Gen. Mgr., Decarie Incinerator Co., 347 McKnight Bldg., Minneapolis, Minn.	April 3, 1895
Carle, Nathaniel Allen. Engr., Puget Sound Bridge & Dredging Co., 432 Central Bldg., Seattle, Wash.	April 4, 1911
Carlile, Thomas Jenks. Prin. Asst. Engr., L. I. R. R., Jamaica, N. Y. *(Jun., Mar. 3, 1896; Assoc. M., Mar. 6, 1901)*	Dec. 3, 1907
Carlin, Joseph Patrick. Secy. and Treas., P. J. Carlin Constr. Co., 16 East 23d St., New York City. *(Jun., Oct. 4, 1898; Assoc. M., Sept. 6, 1905)*	May 31, 1910
Carll, David Sylvanus. Second Vice-Pres. and Gen. Mgr., Capital Traction Co., Washington, D. C. *(Jun., Mar. 7, 1888; Assoc. M., July 1, 1891)*	Oct. 7, 1896
Carmalt, Laurance Johnson. Asst. Engr., N. Y., N. H. & H. R. R., 144 Water St., New Haven, Conn.	May 1, 1907
Carpenter, Allan Wadsworth. Engr. of Structures, N. Y. C. & H. R. R. R., 7th Floor, Grand Central Palace, New York City (Res., 68 Arthur St., Yonkers, N. Y.). *(Jun., Mar. 5, 1901; Assoc. M., April 1, 1903)*	Sept. 1, 1908
Carpenter, Charles Lincoln. Supt., Ponce & Guayama R. R., Central Aguirre, Porto Rico	Dec. 6, 1905
Carpenter, George Ansel. City Engr., Pawtucket, R. I.	May 7, 1902
Carpenter, Rolla Clinton. Prof. of Experimental Eng. (in Chg. of Research), Sibley Coll., Cornell Univ. (Res., 125 Eddy St.), Ithaca, N. Y.	April 4, 1911
Carr, Albert. 68 Carnegie Ave., East Orange, N. J. *(Assoc. M., Mar. 2, 1892)*	Oct. 7, 1903
Carr, Walter Frank. Chf. Engr., The Falk Co., Milwaukee, Wis.	June 6, 1894
Carroll, Eugene. Chf. Engr. and Mgr., Butte Water Co., Butte, Mont. *(Jun., Jan. 4, 1888; Assoc. M., July 1, 1891)*	June 2, 1897
Carson, Howard Adams. Cons. Engr., 79 Glenwood St., Malden, Mass.	Feb. 7, 1894
Carson, William Waller. Prof. of Civ. Eng., Univ. of Tennessee, 1705 Clinch Ave., Knoxville, Tenn.	Nov. 2, 1892
Carter, Alfred Ellsworth. Res. Engr., Rapid Transit Subway Constr. Co. (Res., 706 West 180th St.), New York City. *(Assoc. M., June 4, 1902)*	April 4, 1911
Carter, Edward Carlos. Chf. Engr., C. & N. W. Ry., Chicago, Ill.	April 4, 1888
Carter, Henry Hall. Pres., Met. Contr. Co., and Cons. Engr., 95 Milk St., Boston, Mass.	May 7, 1890
Carter, J. Rivers. Birmingham, Ala.	Feb. 3, 1892
Carter, Richard William. Bridge Engr., Key West Extension, Florida East Coast Ry., Marathon, Fla. *(Assoc. M., Oct. 1, 1902)*	Jan. 2, 1912
Carter, Shirley. Asst. Engr., U. S. Engr. Dept., Norfolk, Va. *(Jun., May 31, 1892; Assoc. M., Oct. 5, 1898)*	Dec. 4, 1906
Carter, William J. Cons. Engr., 1315 Rockefeller Bldg., Cleveland, Ohio. *(Jun., Feb. 5, 1895; Assoc. M., Sept. 7, 1898)*	Nov. 1, 1904
Cartlidge, Charles Hopkins. Bridge Engr., C., B. & Q. R. R., 226 West Adams St., Chicago, Ill.	May 4, 1904
Carven, Christopher James. Engr. of Maintenance, Water Service, Public Works Dept., 44 City Hall, Boston, Mass.	April 4, 1911
Cary, Edward Richard. Prof. of Geodesy and Railroad Eng., Rensselaer Polytechnic Inst., Troy, N. Y.	April 2, 1902
Case, James Francis. Vice-Pres., Cuban Eng. & Contr. Co., Arsenal 2, Havana, Cuba	Jan. 6, 1904
CATTELL, WILLIAM ASHBURNER. *(Director)*. Cons. Engr., Foxcroft Bldg., San Francisco, Cal. *(Assoc. M., May 6, 1891)*	Oct. 7, 1896
Chadbourn, William Hobbs, Jr. Valuation Engr., L. V. R. R., 16 Winchester St., Brookline, Mass. *(Jun., Dec. 3, 1890)*	Mar. 1, 1905
Chamberlain, Phillip William. Toro Amarillo P. O., Costa Rica	Oct. 2, 1895
Chamberlin, Chester Harvey. Asst. Chf. Engr., Tex. & Pac. Ry., Dallas, Tex.	Oct. 5, 1904
Chambers, Frank Taylor. Civ. Engr., U. S. N., Bureau of Yards and Docks, Navy Dept., Washington, D. C. *(Assoc. M., April 6, 1898)*	Mar. 3, 1903
Chambers, Herbert James. Steel Engr. and Contr. (Hamilton & Chambers), 29 Broadway, New York City. *(Assoc. M., Nov. 5, 1902)*	Jan. 3, 1911
Chambers, Ralph Hamilton. Care, The Foundation Co., 115 Broadway, New York City. *(Assoc. M., Dec. 1, 1897)*	April 5, 1904
Chapin, Loomis Eaton. Cons. Engr., 14 Central Savings Bank Bldg., Canton, Ohio. *(Jun., Dec. 3, 1884; Assoc. M., Sept. 7, 1892)*	Nov. 4, 1896
Chapleau, Samuel Jefferson. Res. Engr., Public Works Dept., Ottawa, Ont., Canada. *(Assoc. M., May 1, 1901)*	Jan. 31, 1905
Chapman, James Russell. 1712 Anacapa St., Santa Barbara, Cal.	Mar. 6, 1901
Chappell, Thomas Fenning. 215 West 125th St., Room 39, New York City	Oct. 5, 1904

	Date of Membership
Chase, Charles Francis. Cons. Engr., 75 Westminster St., Providence, R. I.	Jan. 1, 1896
Chase, Charles Francis. Chf. Engr., Berlin Constr. Co., Berlin (Res., 241 West Main St., New Britain), Conn.	Feb. 5, 1902
Chase, Frank Lynton. Pres., The Central Contract & Finance Co., 821 Columbus Savings and Trust Bldg., Columbus, Ohio. (*Assoc. M., Nov. 4, 1896*)	Nov. 1, 1899
Chase, John Carroll. Derry Village, N. H.	Mar. 1, 1893
Chase, Marvin. Pres., Whitestone Irrig. & Power Co., Richmond Beach, Wash.	June 5, 1907
Cheever, Albert Safford. Supt., Fitchburg Div., B. & M. R. R., Boston, Mass.	June 7, 1893
Cheney, Herbert Neal. Engr. of Constr., Boston Consolidated Gas Co., Hilton St., Roxbury, Mass. (*Assoc. M., Feb. 6, 1907*)	Sept. 1, 1908
Chester, John Needels. Cons. Engr. (Chester & Fleming), Union Bank Bldg., Pittsburgh, Pa. (*Jun., Dec. 6, 1892; Assoc. M., Dec. 5, 1894*)	Mar. 6, 1901
Chew, Richard Sanders. 607 Humboldt Bank Bldg., San Francisco, Cal. (*Assoc. M., Sept. 5, 1906*)	June 30, 1911
Chibas, Eduardo Justo. Cons. Engr. and Contr., Apartado 54, Santiago de Cuba, Cuba. (*Jun., Mar. 31, 1891; Assoc. M., May 6, 1896*)	Jan. 3, 1900
Child, Stephen. 6 Beacon St., Room 217, Boston, Mass.	Oct. 5, 1898
Childs, James Edmund. Vice-Pres. and Gen. Mgr., N. Y., O. & W. Ry., 56 Beaver St., New York City	Dec. 4, 1878
Childs, Oliver W. 4211 Flad Ave., St. Louis, Mo. (*Assoc. M., Sept. 5, 1900*)	Sept. 3, 1902
Chipman, Willis. (Chipman & Power), Mail Bldg., Toronto, Ont., Canada.	June 6, 1888
Chittenden, Hiram Martin. Brig.-Gen., U. S. A. (*Retired*), 124 Fifteenth Ave., N., Seattle, Wash.	Feb. 7, 1900
Choate, Joseph Kittredge. Gen. Mgr., Otsego & Herkimer R. R., Cooperstown, N. Y.	May 4, 1909
Christian, George Lyon. Asst. Engr., Bureau of Sewers, Borough of the Bronx, East 177th St., and Third Ave. (Res., East 238th St., Woodlawn), New York City. (*Assoc. M., Mar. 6, 1895*)	Oct. 3, 1905
Christian, William Arnold. First Asst. Engr., C. G. W. R. R., Room 463, Grand Central Station, Chicago, Ill.	Oct. 3, 1911
Christie, George B. Civ. Engr. and Contr. (Christie & Lowe), 171 La Salle St., Chicago, Ill.	Oct. 2, 1895
Christie, William Wallace. Cons. Engr., Citizens Trust Bldg., Paterson, N. J.	June 3, 1908
Christy, George Lewis. 128 West 42d St., New York City. (*Jun., June 6, 1893; Assoc. M., Nov. 4, 1896*)	Jan. 31, 1905
Church, Charles Titus. 155 William St., Geneva, N. Y.	May 1, 1889
Church, Fred Bush. 10 Bridge St., New York City	June 3, 1908
Church, William Lee. Pres. and Cons. Engr., Ambursen Hydr. Constr. Co., 176 Federal St., Boston, Mass.	Feb. 6, 1907
CHURCHILL, CHARLES SAMUEL. (*Vice-President*). Chf. Engr., N. & W. Ry., Roanoke, Va.	May 1, 1889
Churchill, John Charles. U. S. Asst. Engr., Oswego, N. Y.	Feb. 1, 1899
Churchill, John Pierce. Engr., Hay Foundry & Iron Works, 19 Whittelsey Ave., East Orange, N. J.	Oct. 31, 1911
Clapp, Joseph Malcolm. Cons. Engr., 504 Burke Bldg., Seattle, Wash.	Nov. 4, 1908
Clapp, Otis Francis. City Engr., City Hall, Providence, R. I.	Mar. 2, 1898
Clark, Charles Henry. Engr., M. of W., Cleveland Rys., Cleveland, Ohio	May 7, 1902
Clark, George Hallett. Engr., Holbrook, Cabot & Rollins Corporation, Dry Dock No. 4, New York Navy Yard; Address, 301 West 109th St., New York City. (*Jun., Oct. 3, 1893; Assoc. M., April 6, 1898*)	Oct. 31, 1905
Clark, Roscoe Nathaniel. City Engr., Hartford, Conn. (*Assoc. M., May 4, 1904*)	Mar. 5, 1907
Clark, Thomas Stevens. Chf. Engr., Alphons Custodis Chimney Cons. Co., 622 Bennett Bldg., New York City	June 3, 1908
Clark, Watson Gerould. Tenafly, N. J.	July 9, 1906
Clarke, David Dexter. Engr., Water Board, Portland, Ore.	July 5, 1882
N. Clarke, Eliot Channing. 15 Brimmer St., Boston, Mass.	Sept. 4, 1878
Clarke, Ernest Wilder. Div. Engr., Board of Water Supply, City of New York, Pleasantville, N. Y.	Jan. 4, 1905
CLARKE, GEORGE CALBRAITH. (*Director*). Member of Firm and Chf. Engr., Fraser, Brace & Co., 1328 Broadway, New York City	June 3, 1903
Clarke, St. John. Bogota, N. J. (*Jun., Sept. 5, 1888*)	June 1, 1904
Clarke, Thomas Curtis. Superv. Engr. for the Deutsche Bank of Berlin, Germany, South Bethlehem, Pa.	May 4, 1909
Clarkson, Robert Cooke. Care, Chas. E. Monday & Co., 1320 Olive St., Philadelphia, Pa. (*Jun., Jan. 5, 1887*)	Jan. 2, 1901
Claussen, Oscar. Commr. of Public Works, and City Engr., St. Paul, Minn.	Oct. 2, 1901

	Date of Membership
Clayton, Robert Morris. City Engr., Atlanta, Ga.	Mar. 4, 1896
Clayton, Thomas Wiley. With Chicago Elev. Rys., 524 West 67th St., Chicago, Ill.	Nov. 6, 1907
Clement, Frank Hudson. Engr. and Contr., Land Title Bldg., Philadelphia, Pa. (Res., 124 West 48th St., New York City)	Nov. 1, 1882
Clermont, John Baptiste. Engr. of Bldg. Constr. with V. J. Hedden & Sons Co., 1 Madison Ave., New York City. (*Assoc. M., May 4, 1904*)	Oct. 6, 1908
Coane, John Montgomery. Civ., Hydr. and Min Engr., 70 Queen St., Melbourne, Victoria, Australia	Nov. 4, 1908
Cochrane, Victor Hugo. Cons. Engr. (Hedrick & Cochrane), 1118 McGee St., Kansas City, Mo. (*Assoc. M., Oct. 4, 1905*)	Dec. 6, 1910
Code, William Henry. Cons. Engr. (Quinton & Code), 605 Wright and Callender Bldg., Los Angeles, Cal.	June 5, 1907
Codwise, Edward Bertie. 298 Wall St., Kingston, Ulster Co., N. Y.	Sept. 5, 1888
Coe, David. Care, T. A. Biorklund, Apartado No. 599, City of Mexico, Mexico	Sept. 7, 1904
Coe, Thomas Hamilton. 1222 Main St., Worcester, Mass.	April 4, 1911
Coe, William Watson. Gen. Mgr., Pocohontas Coal & Coke Co., Roanoke, Va.	April 3, 1889
Coffin, Amory. 12 Riggs Pl., South Orange, N. J.	Mar. 3, 1875
Coffin, Thomas Amory. 309 South Main St., Phœnixville, Pa. (*Jun., Oct. 2, 1894*)	Feb. 1, 1899
Cogswell, William Brown. Vice-Pres. and Managing Director, The Solvay Process Co., Syracuse, N. Y. (*Assoc., Feb. 15, 1871*)	Oct. 16, 1872
Cohen, Frederick William. Engr. of Erection, Bridge and Constr. Dept., The Pennsylvania Steel Co., Steelton, Pa. (*Assoc. M., Feb. 3, 1897*)	Sept. 3, 1902
COHEN, MENDES. (*Past-President*). 825 N. Charles St., Baltimore, Md.	Dec. 4, 1867
Colby, Albert Ladd. Cons. Engr., and Iron and Steel Metallurgist, 447 Lehigh St., South Bethlehem, Pa.	Oct. 7, 1903
Colby, Branch Harris. Cons. Engr., 812 Security Bldg., St. Louis, Mo.	June 5, 1895
Cole, Daniel Webster. Project Engr., U. S. Reclamation Service, Fallon, Nev.	June 7, 1905
Cole, Harry Outen. Res. Engr., Pacific Div., Panama Canal, Corozal, Canal Zone, Panama. (*Assoc. M., Jan. 4, 1905*)	May 3, 1910
Cole, Howard Judson. Const. Engr., 126 East 23d St., New York City. (*Assoc. M., Jan. 6, 1892*)	Mar. 1, 1899
Cole, John Adams. 1346 East 53d St., Chicago, Ill.	Mar. 7, 1894
Cole, William Weeden. Mgr. of Utilities Dept., Dodge & Day, 608 Chestnut St., Philadelphia, Pa.	Oct. 7, 1903
Coleman, Clarence. U. S. Asst. Engr., Engr. Office, U. S. A., Duluth, Minn.	Nov. 3, 1897
Coleman, Frederick Albert. Pres., The J. D. Smith Foundry Supply Co., 1846 Scranton Rd., Cleveland, Ohio. (*Jun., April 4, 1893; Assoc. M., April 5, 1899*)	Dec. 1, 1903
Coleman, John Francis. Cons. Engr., 920 Hibernia Bldg., New Orleans, La.	Oct. 2, 1901
Collier, Bryan Cheves. With H. S. Kerbaugh, Inc., Kensico Dam, Valhalla (Res., Pleasantville), N. Y. (*Assoc. M., Oct. 3, 1900*)	June 4, 1907
Collins, Daniel Charles Newman. Cons. Engr., 29 Broadway, New York City	April 3, 1901
Collins, Roderick Greene, Jr. 1 Madison Ave., New York City	May 4, 1904
Colpitts, Walter William. Chf. Engr., Kans. City, Mex. & Orient Ry., 406 U. S. & Mex. Trust Bldg., Kansas City, Mo.	Nov. 1, 1905
Compton, Charles Sumner. Cons. Engr., Northern Elec. Ry. and E. B. & A. L. Stone Co., Orloff, Butte Co., Cal.	June 3, 1908
Comstock, Charles Worthington. State Engr., Boston Bldg., Denver, Colo. (*Jun., April 5, 1892; Assoc. M., Feb. 7, 1900*)	Sept. 5, 1905
Conard, Clarence Knight. Asst. Engr., Erie R. R., 50 Church St., Room 977, New York City	Oct. 5, 1909
Condron, Theodore Lincoln. Cons. Bridge and Structural Engr., 1214 Monadnock Bldg., Chicago, Ill. (*Assoc. M., Feb. 1, 1899*)	Oct. 2, 1901
Congdon, John Potter. Cons. Engr., Pocatello, Idaho. (*Assoc. M., May 3, 1905*)	Sept. 5, 1911
Conkling, Cloud Clifford. Cons. Civ. Engr., 798 Ellicott Sq. Bldg., Buffalo, N. Y.	Jan. 4, 1905
Conn, Frank Winslow. Care, Hammond Mfg. Co., 54 First St., Portland, Ore.	June 1, 1904
Connett, Albert Neumann. Chf. Engr., J. G. White & Co., Ltd., 9 Cloak Lane, London, E. C., England. (*Jun., June 6, 1883*)	Oct. 1, 1890
Connick, Harris De Haven. Director of Works, Panama-Pacific International Exposition Co., Exposition Bldg., San Francisco, Cal. (*Jun., Jan. 3, 1899; Assoc. M., Feb. 4, 1903*)	Feb. 1, 1910
Connor, Edward Hanson. Vice-Pres., Mo. Val. Bridge & Iron Co., Leavenworth, Kans. (*Jun., Feb. 5, 1890; Assoc. M., Feb. 3, 1892*)	April 4, 1900
Connor, Samuel Powers. 230 West 107th St., New York City. (*Assoc. M., Nov. 7, 1906*)	Jan. 7, 1908

		Date of Membership
	Connor, William Durward. Maj., Corps of Engrs., U. S. A., Commanding First Battalion of Engrs.; Director of Civ. Eng., U. S. Engr. School, Washington Barracks, Washington, D. C. (*Assoc. M., Jan. 7, 1903*)	May 31, 1910
	Conover, Charles E. Designing Engr., Public Service Comm., 154 Nassau St., New York City	Nov. 1, 1910
	Constable, Howard. Archt., Lyons Falls, Lewis Co., N. Y.	Dec. 7, 1892
	Constant, Frank Henry. Prof. of Structural Eng., Univ. of Minnesota, Minneapolis, Minn. (*Assoc. M., Dec. 2, 1896*)	April 2, 1907
	Contri, Silvio. Archt., 1a General Prim No. 15, City of Mexico, Mexico	July 1, 1908
	Conway, George Robert Graham. Chf. Engr. and Asst. Gen. Mgr., British Columbia Elec. Ry., Vancouver, B. C., Canada	Dec. 4, 1907
	Cook, Frederick Scott. Div. Engr., Dept., Water Supply, Gas and Electricity, 13 Park Row Bldg., New York City (Res., 26 Landscape Ave., Yonkers, N. Y.)	June 3, 1908
	Cook, John Henry. Hydr. Engr., Society for Establishing Useful Manufactures, 158 Ellison St., Paterson, N. J. (*Assoc. M., May 4, 1898*)	Jan. 4, 1910
	Cooley, Lyman Edgar. 22 Quincy St., Room 710, Chicago, Ill.	June 1, 1898
	Cooley, Maurice Wurtz. Gen. Mgr., Vintah Ry., Mack, Colo. (*Assoc. M., Mar. 7, 1894*)	Dec. 3, 1902
	Cooley, Mortimer Elwyn. Prof. of Mech. Eng. and Dean, Dept. of Eng., Univ. of Michigan, Ann Arbor, Mich.	May 2, 1911
	Coombs, Philip Henry. City Hall, Bangor, Me.	Mar. 7, 1906
	Coombs, Robert Duncan. Cons. Engr., 50 Church St., New York City. (*Jun., May 2, 1899; Assoc. M., Feb. 7, 1900*)	Jan. 7, 1908
	Coombs, Stephen Elbridge. 70 East 45th St., Room 5609, New York City	Sept. 3, 1902
	Cooper, Hugh Lincoln. Keokuk, Iowa	Sept. 6, 1905
	Cooper, Samuel Lispenard. City Engr., City Hall, Yonkers, N. Y.	Feb. 6, 1889
N. N.	Cooper, Theodore. 353 West 57th St., New York City	Mar. 4, 1874
	Cornell, George Birdsall. 67 Montclair Ave., Montclair, N. J. (*Jun., Aug. 6, 1879*)	Oct. 6, 1886
	Cornell, John Nelson Hayward. 29 Broadway, New York City. (*Jun., May 1, 1889*)	June 1, 1909
	Corner, Charles. Res. Engr., Rhodesia Rys. (Northern Extensions), Box 422, Buluwayo, Rhodesia, South Africa. (*Assoc. M., May 1, 1895*)	Mar. 5, 1907
	Cornish, Lorenzo Dana. Designing Engr., Isthmian Canal Comm., Culebra, Canal Zone, Panama. (*Jun., April 5, 1904; Assoc. M., Feb. 7, 1906*)	June 30, 1910
	Coroalles, Manuel Alberto. Chf. Engr., Dept. of Public Works, Cerro 440 B, Havana, Cuba	Aug. 31, 1909
	Corry, Thomas Avery. Res. Engr., Ferrocarriles del Sur del Peru, Arequipa, Peru	May 6, 1903
	Corthell, Arthur Bateman. Chf. Engr., B. & M. R. R., North Station, Boston, Mass.	Mar. 1, 1899
	Corthell, Elmer Lawrence. 149 Broadway, New York City	Sept. 2, 1874
	Cory, Harry Thomas. Cons. Engr., 802 Nevada Bank Bldg., San Francisco (Res., 2600 Benvenue Ave., Berkeley), Cal. (*Jun., June 20, 1893; Assoc. M., Mar. 7, 1900*)	Feb. 5, 1907
	Cosby, Spencer. Col., Corps of Engrs., U. S. A., 1729 New York Ave., Washington, D. C.	Oct. 5, 1904
	Cothran, Thomas White. Cons. Engr., Greenwood, S. C. (*Assoc. M., July 9, 1906*)	Feb. 28, 1911
	Cotton, Joseph P. Newport, R. I.	June 7, 1876
	Couchot, Maurice Charles. Room 613 Mechanics Inst. Bldg., San Francisco, Cal. (*Assoc. M., Nov. 1, 1905*)	June 2, 1908
	COURTENAY, WILLIAM HOWARD. (*Director*). Chf. Engr., L. & N. R. R., Louisville, Ky.	July 3, 1889
	Coutlee, Charles Robert Foran. Upper Ottawa Storage, Box 560, Ottawa, Ont., Canada	Mar. 1, 1905
	Coverdale, William Hugh. Cons. Engr., 66 Broadway, New York City. (*Jun., Jan. 2, 1894; Assoc. M., Oct. 3, 1900*)	June 30, 1911
	Cowan, Herbert Wheeler. Chf. Engr., Colo. & South. Ry, 801 Cooper Bldg., Denver, Colo.	June 3, 1908
	Cowles, Walter Linsley. Cons. Engr., 902 Fort Dearborn Bldg., Chicago, Ill.	Mar. 6, 1889
	Cowles, William Pierce. Cons. Engr., 614 Flour Exchange, Minneapolis, Minn. (*Assoc. M., Nov. 7, 1906*)	May 3, 1910
N.	Cox, Leonard Martin. Civ. Engr., U. S. N., Navy Yard, Norfolk, Va. (*Assoc. M., Oct. 4, 1899*)	Jan. 5, 1904
	Crandall, Charles Lee. Prof. of Ry. Eng., Cornell Univ., Ithaca, N. Y. (*Jun., June 7, 1876*)	Oct. 5, 1892
	Crandall, Charles Leo. Vice-Pres., Bowers Southern Dredging Co.; Secy., Furst-Clark Constr. Co., Security Bldg., Galveston, Tex.	May 4, 1909
	Crane, Albert Sears. Chf. Hydr. Engr., J. G. White & Co., 49 Exchange Pl., New York City. (*Jun., Sept. 3, 1895; Assoc. M., May 4, 1898*)	May 1, 1901

	Date of Membership
CRANE, CLARENCE AUSTIN. Cons. Engr., 21 Park Row, New York City. *(Assoc. M., Mar. 5, 1902)*	May 4, 1909
CRANE, FRANCIS ELIHU. City Engr., Amsterdam, N. Y.	Oct. 1, 1902
CRAVEN, ALFRED. Chf. Engr., Public Service Comm., First Dist., 154 Nassau St., New York City	Dec. 5, 1888
CRAWFORD, JOSEPH EMMANUEL. Bridge Engr., N. & W. Ry., Roanoke, Va. *(Jun., Dec. 5, 1899)*	June 3, 1908
CRAWFORD, WILLIAM. Address unknown	Nov. 7, 1888
CRECELIUS, SAMUEL FORDER. 403 Equitable Bldg., Louisville, Ky	Dec. 4, 1907
CREHORE, WILLIAM WILLIAMS. Cons. Engr., 30 Church St., New York City. *(Assoc. M., April 4, 1894)*	Sept. 3, 1902
CRELLIN, EDWARD WEBSTER. Pres., Des Moines Bridge & Iron Works, Curry Bldg., Pittsburgh, Pa	Mar. 2, 1909
CRESSON, BENJAMIN FRANKLIN, JR. First Deputy Commr., Dept. of Docks and Ferries, Pier A, North River, New York City. *(Assoc. M., April 2, 1902)*	Jan. 7, 1908
CREUZBAUR, ROBERT WALTER. Cons. Engr. of Public Works, 30 Church St., New York City. *(Jun., April 2, 1890; Assoc. M., April 4, 1894)*	April 4, 1900
CREW, CHARLES CORWIN. Gen. Mgr., A. Wyckoff & Son Co. of La., Alexandria, La. *(Assoc. M., April 1, 1903)*	June 1, 1909
CRIDER, JAMES LELAND. Chf. Engr., N. Y., Westchester & Boston Ry.; Chf. Engr., Westchester Northern R. R., 70 East 45th St., Room 3144, New York City	Jan. 3, 1906
CROCKARD, FRANK HEARNE. Vice-Pres. and Gen. Mgr., Tennessee Coal, Iron & R. R. Co., Birmingham, Ala	Oct. 4, 1910
CROCKER, HERBERT SAMUEL. Cons. Engr., 308 Tramway Bldg., Denver Colo.	Oct. 2, 1901
CROSBY, BENJAMIN LINCOLN. Div. Engr., N. P. Ry., Tacoma, Wash. *(Jun., June 2, 1880)*	Oct. 6, 1886
CROSBY, HORACE. 38 Trinity Pl., New Rochelle, N. Y	Feb. 17, 1869
CROSBY, WALTER WILSON. Chf. Engr., Md. Geologic and Economic Survey; Chf. Engr., Md. Roads Comm., Baltimore, Md	July 10, 1907
CROSWELL, THOMAS HENRY. E. 8 Hill Ave., Spokane, Wash	Oct. 7, 1908
CROWELL, FOSTER. Cons. Civ. Engr., 18 Broadway, New York City	Dec. 1, 1880
CROZIER, WILLIAM. Brig.-Gen., Chf. of Ordnance, U. S. A., War Dept. (Res., 1745 N St., N. W.), Washington, D. C	Feb. 1, 1905
CRUMP, RALPH LEE. Care, Ford, Bacon & Davis, 921 Canal St., New Orleans, La	Dec. 3, 1902
CUDDEBACK, ALLAN WINTER. Engr. and Supt., Passaic Water Co., Paterson, N. J. *(Assoc. M., April 5, 1899)*	Mar. 1, 1910
CULLEN, JAMES FRANCIS. Asst. Engr. of Constr., P. R. R., 510 South 48th St., Philadelphia, Pa	May 2, 1906
CUMMINGS, ELMORE DAVID. U. S. Asst. Engr., Office, Chf. of Engrs., U. S. A., 302 Custom House, Baltimore, Md. *(Assoc. M., Nov. 4, 1903)*.	June 30, 1911
CUMMINGS, ROBERT AUGUSTUS. Civ. and Cons. Engr., Pittsburgh, Pa. *(Jun., Oct. 1, 1890; Assoc. M., May 4, 1892)*	June 1, 1898
CUMMINGS, WILLIAM WARREN. Cons. and Const. Engr., Hanover, N. H.	June 7, 1899
CUNNINGHAM, ANDREW CHASE. Civ. Engr., U. S. N.; Insp. of Public Works, Navy Dept., Washington, D. C. *(Assoc. M., Sept. 2, 1891)*	Oct. 3, 1894
CUNNINGHAM, ANDREW OSWALD. Chf. Engr., Wabash R. R., Lincoln Trust Bldg., St. Louis, Mo	Feb. 5, 1902
CUNNINGHAM, DAVID WEST. 627 West 18th St., Los Angeles, Cal	May 7, 1873
CUNNINGHAM, JAMES HENRY. 2 Ravelston Pl., Edinburgh, Scotland	Aug. 6, 1879
CUNNINGHAM, JOSEPH HOOKER. Cons. Hydr. Engr., Sherlock Bldg., Portland, Ore. *(Assoc. M., Sept. 6, 1899)*	Feb. 2, 1904
CURTIS, CHARLES ELBERT. Civ. Engr., Cambria Steel Co., Capital Hotel, Johnstown, Pa	Oct. 4, 1905
CURTIS, FAYETTE SAMUEL. Pres., Old Colony R. R., Boston, Mass	April 3, 1889
CURTIS, LOREN BRADLEY. 254 Coronado Bldg., Denver, Colo. *(Assoc. M., July 10, 1907)*	Nov. 1, 1910
CURTIS, VARNUM PIERCE. Cons. Engr. and Contr., 96 Stafford St., Worcester, Mass. *(Assoc. M., Dec. 7, 1904)*	May 2, 1911
CURTIS, WALTER WHALEY. Cons. Engr., 537 South Dearborn St., Chicago, Ill	Sept. 5, 1888
CUSHING, EDWARD BENJAMIN. Chf. Engr., Constr., Sunset Central Lines, 902 Southern Pacific Bldg., Houston, Tex	Nov. 1, 1893
CUSHING, WILLIAM CHANNING. Chf. Engr., M. of W., South-West System, Penn. Lines, Union Station, Pittsburgh, Pa. *(Jun., June 5, 1889; Assoc. M., Nov. 4, 1891)*	May 1, 1901
CUSHMAN, WILLIAM HERBERT. 235 Cayuga St., Fulton, N. Y	Jan. 3, 1906
DABNEY, AUGUSTINE LEE. Chf. Engr., Tallahatchie Drainage Comm., Clarksdale, Miss	Oct. 2, 1901
DABNEY, THOMAS GREGORY. Chf. Engr., Yazoo-Mississippi Delta Levee Dist., Clarksdale, Miss	Jan. 3, 1906

	Date of Membership
Daggett, Herbert Chapin. New England Mgr. and Engr., S. Morgan Smith Co., 176 Federal St., Boston, Mass.	July 10, 1907
Dahm, Sverre. Gen. Insp. of Designs, Public Service Comm. for the First Dist., 154 Nassau St., New York City	Feb. 7, 1906
Dakin, Albert Harlow, Jr. 370 St. Nicholas Ave., New York City	April 1, 1903
Dallis, Park Andrew. Mill Archt. and Engr., 913 Candler Bldg., Atlanta, Ga. (*Assoc. M., June 1, 1904*)	Jan. 4, 1910
Dalton, B. J. Assoc. Prof. of Railway Eng., Univ. of Kansas, 1011 Indiana St., Lawrence, Kans.	Oct. 2, 1907
Damon, Albert Forster, Jr. Cons. Engr., P. O. Bldg., Darby, Pa.	Oct. 3, 1911
Dana, Richard Turner. Civ. and Cons. Engr., 15 William St., New York City. (*Jun., Sept. 11, 1900; Assoc. M., Feb. 4, 1903*)	Jan. 7, 1908
Danforth, Frederic. Cons. Engr.; Chf. Engr., Eastern Maine R. R., 29 Pleasant St., Gardiner, Me.	Sept. 2, 1891
Danforth, Richard Eugene. Gen. Mgr., Public Service Ry., Broad and Bank Sts., Newark, N. J.	Oct. 3, 1906
Darling, Fred Steere. Engr., M. of W., B. & M. R. R., Boston, Mass.	Oct. 7, 1903
Darling, John Henry. U. S. Prin. Asst. Engr., 532 West Third St., Duluth, Minn.	May 1, 1901
Darling, William Lafayette. Chf. Engr., N. P. Ry., St. Paul, Minn.	Oct. 5, 1892
Darnell, James Lee. Mgr., Wm. P. Carmichael Co., 511 New England Bldg., Kansas City, Mo.	Oct. 4, 1910
Darrach, Charles Gobrecht. Cons. Engr., 4144 Poplar St., Philadelphia, Pa.	Jan. 5, 1876
Darrow, Frank Tenney. Engr., M. of W., C., B. & Q. R. R. Lines West, Lincoln, Nebr. (*Assoc. M., May 1, 1907*)	May 4, 1909
Dart, Carlton Rollin. Bridge Engr., San. Dist. of Chicago, 1500 Am. Trust Bldg., Chicago, Ill.	May 6, 1903
Dart, Justus Vinton. Asst. Engr. in Chg. of Highway Dept., City Hall, Providence, R. I.	April 4, 1900
Datesman, George Elvin. Prin. Asst. Engr., Bureau of Surveys, 416 City Hall, Philadelphia, Pa.	Feb. 4, 1903
Dauchy, Walter Edward. 1526 West 8th St., Riverside, Cal.	Nov. 4, 1903
Davenport, James Aubrey. Asst. Engr., N. & W. Ry. (Res., 402 Fourteenth Ave., S. W.), Roanoke, Va.	April 5, 1905
Davidson, Frank Eugene. Archt. and Cons. Engr. (Patterson & Davidson), 1448 Monadnock Blk. (Res., 7436 Kimbark Ave.), Chicago, Ill.	Nov. 4, 1908
Davies, John Vipond. Cons. Engr. (Jacobs & Davies), 30 Church St., New York City	June 6, 1894
Davis, Arthur Lincoln. Div. Mgr., Am. Bridge Co., 30 Church St., New York City. (*Jun., April 4, 1893; Assoc. M., Oct. 7, 1896*)	Mar. 6, 1906
Davis, Arthur Powell. Chf. Engr., U. S. Reclamation Service, Washington, D. C. (*Assoc. M., June 7, 1893*)	Oct. 4, 1899
Davis, Carleton Emerson. Dept. Engr., Board of Water Supply, City of New York, Brown Station, N. Y. (*Assoc. M., April 6, 1898*)	Mar. 3, 1908
Davis, Chandler. 11 Broadway, New York City. (*Jun., Dec. 3, 1890; Assoc. M., Feb. 6, 1895*)	Oct. 4, 1899
Davis, Charles E. L. B. Brig.-Gen., U. S. A. (*Retired*), 240 East 9th St., Plainfield, N. J.	July 12, 1877
Davis, Charles Henry. South Yarmouth, Mass.	Dec. 4, 1895
Davis, Charles Stratton. Cons. Engr., 431 Spitzer Bldg., Toledo, Ohio.	Feb. 1, 1905
Davis, Chester Birge. Cons. Engr., 90 West St., Room 1416, New York City	Feb. 1, 1882
Davis, John Rose Wilson. Engr., M. of W., G. N. Ry. Line, St. Paul, Minn.	Nov. 4, 1903
Davis, Joseph Baker. Dexter, Mich. (*Jun., April 1, 1874*)	Oct. 5, 1898
Davis, Joseph Phineas. 332 Palisade Ave., Yonkers, N. Y.	Jan. 29, 1868
Davis, Leonard Henry. Gen. Mgr. and Chf. Engr., The Michigan Lake Superior Power Co., Sault Ste. Marie, Mich. (*Assoc. M., Nov. 5, 1902*)	May 4, 1909
Davis, Lynn LeRoy. U. S. Asst. Engr., 540 Federal Bldg., Buffalo, N. Y.	Nov. 30, 1909
Davis, Noah Wilson. Harrisonburg, Va.	July 9, 1906
Davis, Robert Benjamin. Designing Engr., Boston Elev. Ry., 101 Milk St., Boston, Mass.	July 3, 1889
Davison, George Stewart. Pres., Gulf Refining Co., Frick Annex, Pittsburgh, Pa.	April 2, 1890
Dawley, William Sanborn. Chf. Engr., Yunnan-Szechuan & Tengyueh Ry., Yunnanfu, Yunnan Prov., China	Oct. 4, 1905
Dawson, Edwin Ford. Asst. to Chf. Engr., P. & R. Ry., Room 516, Reading Terminal, Philadelphia, Pa.	Mar. 4, 1908
Dean, Arthur Warren. Chf. Engr., Mass. Highway Comm., 15 Ashburton Pl., Boston, Mass.	May 4, 1904
Dean, Bertram Dodd. Chf. Engr., Puget Sound Bridge & Dredging Co., 2322 Thirty-second Ave., South, Seattle, Wash.	Aug. 31, 1909
Dean, Luther. 4 Clinton St., Taunton, Mass.	May 4, 1898

	Date of Membership
DEANS, JOHN STERLING. Chf. Engr., The Phœnix Bridge Co., Phœnixville, Pa.	May 4, 1887
DECROW, DAVID AUGUSTUS. Chf. Engr. and Secy., Snow Steam Pump Works, Buffalo, N. Y.	Oct. 4, 1910
DEEN, JAMES WORK. Div. Engr., D. & R. G. R. R., Salida, Colo.	Jan. 6, 1892
DEFREES, MORRIS M. Indianapolis, Ind.	Mar. 3, 1880
DEGEN, OTTO WILLIAM. Supt. of Constr., Quartermaster's Dept., U. S. A., 1718 St. Charles St., Alameda, Cal.	April 5, 1910
DE LA BARRE, WILLIAM. Engr., Agt. and Treas., St. Anthony Falls Water Power Co., Minneapolis, Minn.	April 5, 1893
DELANO, FREDERIC ADRIAN. Receiver, The Wabash R. R., 514 Western Union Bldg., Chicago, Ill.	June 4, 1902
DELANO, HARRY CLARK. Care, Civil Govt., San Juan, Porto Rico	Jan. 3, 1911
DENCER, FREDERICK WILLIAM. Engr., Gary Plant, Am. Bridge Co., Gary, Ind. (*Assoc. M., Feb. 7, 1906*)	Nov. 8, 1909
DENISE, CHARLES MEIRS. Contr. Engr., Chicago Office, McClintic-Marshall Constr. Co., 1214 First National Bank Bldg., Chicago, Ill.	May 3, 1910
DENNIS, ARTHUR CRISFIELD. Mgr., Foley, Welch & Stewart, 202 Chambers of Commerce, Winnipeg, Man., Canada	Dec. 4, 1901
R. DENNIS, WILLIAM FRANKLIN. Cons. Engr.; Vice-Pres., Rinehart & Dennis Co., 1509 Sixteenth St., Washington, D. C.	Feb. 1, 1888
DERBY, GEORGE MCCLELLAN. Lt.-Col., U. S. A. (*Retired*), 1015 Carrollton Ave., New Orleans, La.	April 1, 1896
DERLETH, CHARLES, JR. Prof., Civ. Eng., Univ. of California, Berkeley, Cal. (*Jun., Feb. 1, 1898; Assoc. M., Mar. 5, 1902*)	May 5, 1908
DERRICK, GUY HAMILTON. Box 592, Pulaski, Va.	May 3, 1910
DERRICK, HENRY CLAY. Houston, Halifax Co., Va.	Oct. 5, 1887
DE VARONA, IGNACIO MAREA. Chf. Engr., Dept. of Water Supply, Gas and Electricity, 13 Park Row Bldg., New York City	April 7, 1886
DEVELIN, RICHARD GRIFFITH. Asst. Engr., M. W., Bridges and Bldgs., P. R. R., Broad St. Station, Philadelphia, Pa.	May 1, 1907
DEVIN, GEORGE. 1216 Astor St., Chicago, Ill.	Sept. 7, 1887
DE WITT, PHILIP HOFFECKER. Contr. and Engr., S. B. Mutchler & Co., Phillipsburg, N. J.	May 5, 1897
DEYO, SOLOMON LEFEVRE. Chf. Engr., Interborough Metropolitan Co., 2108 Fifth Ave., New York City	June 6, 1888
DE YOUNG, ISAAC. U. S. Asst. Engr., Sault Ste. Marie, Mich. (*Assoc. M., Dec. 5, 1906*)	Jan. 4, 1910
DIDIER, PAUL. Prin. Asst. Engr., B. & O. R. R., North Side, Pittsburgh, Pa.	Mar. 6, 1889
DIEBITSCH, EMIL. Vice-Pres., John Pierce Co., 90 West St., New York City (Res., 38 Burnett Pl., Nutley, N. J.). (*Jun., Feb. 28, 1893; Assoc. M., Oct. 6, 1897*)	Mar. 5, 1902
DIECK, ROBERT GEORGE. 391 Main St., Portland, Ore. (*Assoc. M., Nov. 6, 1907*)	Feb. 28, 1911
DIEHL, GEORGE CONRAD. County Engr., 575 Ellicott Sq., Buffalo, N. Y.	May 31, 1910
DIEHR, ALVAH BENJAMIN. U. S. Junior Engr., Box 1017, Memphis, Tenn. (*Assoc. M., Nov. 5, 1902*)	July 1, 1909
DILLENBECK, CLARK. Civ. Engr. and Archt.; Asst. Engr., P. & R. Ry., 502 Reading Terminal, Philadelphia, Pa.	June 1, 1904
DILLMAN, GEORGE LINCOLN. Nevada National Bank Bldg., San Francisco, Cal.	Mar. 4, 1891
DIMOCK, ARTHUR HERBERT. City Engr., Seattle, Wash.	May 31, 1910
DIMON, DANIEL YOUNG. With Eastern Steel Co., 60 Broadway, New York City (Res., 315 Paulison Ave., Passaic, N. J.). (*Assoc. M., Oct. 2, 1901*)	Mar. 31, 1908
DIXON, CHARLES YOUNG. U. S. Asst. Engr., River and Harbor Impvts., Amherstburg, Ont., Canada	Nov. 4, 1903
DOANE, WALTER A. Meadville, Pa.	Sept. 7, 1881
DOBLE, WILLIAM ASHTON. 7th and South Sts., San Francisco, Cal.	April 5, 1905
DOBSON, ADNA. City Engr., Lincoln, Nebr.	May 6, 1908
DOCKWEILER, JOHN HENRY. Cons. Engr., 417 Grant Bldg., San Francisco, Cal.	May 2, 1906
DODGE, JAMES LYNN. 65 Forest Rd., Ridgewood, N. J.	July 1, 1908
DOERFLING, RICHARD GEORGE. Civ. and Cons. Engr., Monadnock Bldg., San Francisco, Cal. (*Assoc. M., June 3, 1903*)	Mar. 5, 1907
DOMENECH, MANUEL VICTOR. P. O. Box 613, Ponce, Porto Rico	July 9, 1906
DONHAM, BENJAMIN CURTIS. (B. C. Donham & Co.), 52 Broadway, New York City. (*Assoc. M., Jan. 2, 1901*)	Mar. 31, 1908
DONOVAN, CORNELIUS. Prin. Asst. Engr., U. S. Engr. Office, Custom House, New Orleans, La.	Oct. 4, 1899
DONOVAN, JOHN JOSEPH. Pres., Lake Whatcom Logging Co.; Vice-Pres., First National Bank, Bellingham, Wash. (*Jun., April 7, 1886*)	April 4, 1888
DOREMUS, ABRAHAM FAIRBANKS. Cons. Engr., Salt Lake City, Utah	Oct. 4, 1893
DORR, EDGAR SUTTON. Chf. Engr., Sewer Div., Street Dept., 30 Tremont St., Boston, Mass.	April 3, 1895

	Date of Membership
Dose, Henry Frederick. Chf. Engr., Madeira-Mamoré Ry., Caixa No. 304, Manãos, Brazil	Jan. 6, 1904
dos Santos, José Americo. Cons. Civ. Engr., Caixa 748, Rio de Janeiro, Brazil	Oct. 7, 1908
Dougan, William Thomas. Engr., M. of W., Met. Street Ry., 775 Seventh Ave., New York City	Oct. 2, 1907
Douglas, Edward Morehouse. Geographer, U. S. Geological Survey, Washington, D. C	Dec. 4, 1901
Douglas, Walter Jules. Care, William Barclay Parsons, Cons. Engr., 60 Wall St., New York City	April 3, 1907
Dow, Alex. Vice-Pres. and Gen. Mgr., The Edison Illuminating Co., 18 Washington Ave., Detroit, Mich	Dec. 5, 1906
Downey, Archibald Stewart. Cons. and Const. Engr., 631 Hoge Bldg., Seattle, Wash	Nov. 30, 1909
Downs, Lawrence Aloysius. Supt., I. C. R. R., Fort Dodge, Iowa	Sept. 6, 1910
Doyle, John Stephen. 2451 Maryland Ave., Baltimore, Md. *(Assoc. M., Nov. 7, 1906)*	May 3, 1910
Dozier, Melville, Jr. Pres., Dozier Constr. & Eng. Co., 607 Nicolaus Bldg., Sacramento, Cal	Oct. 31, 1911
Drake, Albert Bailey. 164 William St., New Bedford, Mass	Oct. 4, 1893
Drake, William Abial. Gen. Mgr. and Vice-Pres., S. F., P. & P. Ry., Prescott, Ariz	Dec. 5, 1883
Drury, Edmund Hazen. Care, The Chilian Longitudinal Ry., Antofagasta, Chili	Oct. 4, 1905
Du Bois, Augustus Jay. Prof. of Civ. Eng., Sheffield Scientific School, New Haven, Conn. *(Jun., July 7, 1875)*	Oct. 5, 1892
Duffies, Edward John. U. S. Asst. Engr., Rivers and Harbors Div., Chf. of Engr.'s Office, War Dept., Washington, D. C	Jan. 3, 1906
Dufresne, Alexander Ritchie. Asst. Chf. Engr., Public Works Dept., Ottawa, Ont., Canada	Jan. 31, 1911
Duggan, George Herrick. Chf. Engr., Dominion Bridge Co., Ltd., Montreal, Que., Canada	Oct. 2, 1895
Duis, Frederick Bernhardt. Asst. Engr., U. S. Engr. Office, P. O. Box 75, Wheeling, W. Va. *(Assoc. M., Dec. 5, 1906)*	Jan. 3, 1911
Duncan, Lindsay. Mech. Engr., Steptoe Val. Smelting & Min. Co., McGill, Nev. *(Assoc. M., Feb. 3, 1904)*	Nov. 2, 1908
Duncklee, John Butler. Cons. Engr., 35 Fairview Ave., South Orange, N. J	April 2, 1873
Dunham, Herbert Franklin. 220 Broadway, New York City	Oct. 1, 1890
Dunham, Lewis Augustus. 42 Broadway, New York City	June 3, 1903
Dunham, William Robert, Jr. Asst. Engr., The Connecticut Co., Box 1063, New Haven, Conn	July 9, 1906
Dunlap, De Clermont. Pres., Dunlap Eng. Operating Co., Marquette Bldg., Chicago, Ill	Jan. 4, 1888
Dunlap, Frederic Clark. Chf. Engr., Bureau of Water, 790 City Hall, Philadelphia, Pa	June 1, 1904
Dunn, Daniel Burke. Chf. Engr., Macon, Dublin & Savannah R. R., Macon, Ga	Dec. 2, 1891
Durham, Henry Welles. Res. Engr., Cape Cod Canal, Cape Cod Constr. Co., Sandwich, Mass	Oct. 5, 1909
Duryea, Edwin, Jr. Civ. and Min. Engr. (Duryea, Haehl & Gilman), 1314 Humboldt Bank Bldg., San Francisco, Cal. *(Jun., Feb. 2, 1887; Assoc. M., Sept. 4, 1895)*	Feb. 2, 1898
Dyer, Arthur James. Pres. and Chf. Engr., Nashville Bridge Co., Nashville, Tenn. *(Assoc. M., Mar. 6, 1901)*	Feb. 4, 1903
Earl, George Goodell. Room 502, City Hall Annex, New Orleans, La. *(Jun., May 7, 1890; Assoc. M., Dec. 2, 1891)*	April 4, 1894
Earle, Thomas. Supt., Bridge and Constr. Dept., Pennsylvania Steel Co., Steelton, Pa	Mar. 6, 1907
Early, Percy Walker. Mgr., Mason & Hanger Co., Woburn, Ky	Jan. 3, 1911
Easby, Marmaduke Ward. Cons. Engr., 1420 Chestnut St., Philadelphia, Pa. *(Assoc. M., Nov. 4, 1891)*	Dec. 1, 1897
Easby, William, Jr. Prof. of Municipal Eng., Univ. of Pennsylvania, Philadelphia, Pa	Jan. 4, 1905
Easterbrook, Frederick James. 82 York Sq., New Haven, Conn	May 3, 1905
Eastwood, John Thompson. Prin. Asst. Engr., Sewerage and Water, Sewerage and Water Board, New Orleans, La. *(Jun., Mar. 6, 1894; Assoc. M., Feb. 1, 1899)*	Sept. 6, 1904
Eaton, Frederick. Big Pine, Cal	May 5, 1886
Eavenson, Howard Nicholas. Chf. Engr., United States Coal & Coke Co., Gary, McDowell Co., W. Va. *(Assoc. M., Mar. 6, 1901)*	May 1, 1906
Eber, John William. Supt., N. Y. C. & H. R. R. R., Utica, N. Y. *(Assoc. M., Sept. 4, 1907)*	Sept. 6, 1910

MEMBERS E

	Date of Membership
Eckart, Nelson Andrew. Res. Engr., Snow Mountain Water & Power Co., 3014 Clay St., San Francisco, Cal. (*Assoc. M., Nov. 1, 1905*)	Jan. 3, 1911
Eckart, William Roberts. Cons. Engr., 3014 Clay St., San Francisco, Cal.	Jan. 5, 1881
Eckersley, Joseph Oscar. 4269 White Plains Ave., New York City	Aug. 31, 1909
Eckles, Harry Edward. 2923 Holmes St., Kansas City, Mo.	Dec. 5, 1911
Eddy, Albert Clark. Asst. Engr., G. N. Ry., 320 Second St., New Westminster, B. C., Canada	Dec. 6, 1910
Eddy, Harrison Prescott. Cons. Engr. (Metcalf & Eddy), 14 Beacon St., Boston, Mass. (*Assoc. M., May 7, 1902*)	Jan. 3, 1907
Edes, William Cushing. Chf. Engr., N. W. Pac. R. R., 909 Phelan Bldg., San Francisco, Cal. (*Jun., Sept. 1, 1886*)	Nov. 4, 1896
Edwards, Harry Winter. Civ. and Cons. Engr., 15 Wall St., New York City	June 4, 1890
Edwards, James Harvey. Asst. Chf. Engr., Am. Bridge Co. of N. Y., 103 Lafayette Ave., Passaic, N. J. (*Jun., May 31, 1892; Assoc. M., May 2, 1894*)	May 4, 1898
Edwards, Warrick Rigeley. Asst. Engr. of Bridges, B. & O. R. R., Baltimore, Md. (*Assoc. M., April 4, 1900*)	Sept. 6, 1910
Ehle, Boyd. 34 East Radford St., Yonkers, N. Y. (*Assoc. M., Jan. 3, 1894*)	Feb. 1, 1910
Eidlitz, Otto Marc. Engr. and Builder, 489 Fifth Ave., New York City.	Sept. 2, 1902
Eldridge, Chauncey. 53 State St., Boston, Mass.	May 2, 1906
Eldridge, Griffith Morgan. Mgr., Eldridge Drug Stores, Americus, Ga. (*Assoc. M., June 1, 1892*)	Sept. 3, 1902
Ellery, Nathaniel. State Engr. of California, Sacramento, Cal.	Nov. 8, 1909
Elliott, Charles Gleason. Chf. of Drainage Investigations, U. S. Dept. of Agriculture, Washington, D. C.	Sept. 3, 1890
Elliott, James Rutherford. Cons. Engr., Arlington Sta., Riverside, Cal. (*Assoc. M., Sept. 4, 1901*)	April 5, 1904
Elliott, James William. 17 Adsit Pl., Burlington, Vt. (*Assoc. M., April 6, 1909*)	June 30, 1910
Ellis, George Ezra. Signal Engr., Kansas City Terminal Ry., 23d St. and Grand Ave., Kansas City, Mo. (*Jun., Mar. 2, 1897; Assoc. M., Mar. 7, 1900*)	Dec. 4, 1901
Ellis, John Waldo. Cons. Engr., Woonsocket, R. I.	July 3, 1895
Ellsworth, Emory Alexander. Civ. and Hydr. Engr., 18 Dwight St., Holyoke, Mass.	June 1, 1904
Elmer, Howard Nixon. Gen. Agt. in North America, Siebe, Gorman & Co., Ltd., 1140 Monadnock Blk., Chicago, Ill.	April 7, 1886
Elwell, Charles Clement. Chf. Engr, Public Utilities Comm., State of Connecticut, Box 765, New Haven, Conn.	July 1, 1891
Ely, Theodore Newel. Bryn Mawr, Pa.	Mar. 2, 1881
Emerson, Guy Carleton. Cons. Engr., Boston Finance Comm., 410 Tremont Bldg., Boston, Mass.	May 4, 1904
Emery, James Albert. Cons. Engr. with Ford, Bacon & Davis, 115 Broadway, New York City	June 4, 1902
Emig, John Witmer. Chf. Engr., A. Bolter's Sons, Belden Ave. and Ward St., Chicago, Ill.	Oct. 5, 1909
Endemann, Herman Karl. Asst. Engr. in Chg., Topographical Bureau, Borough of Queens, 252 Jackson Ave., Long Island City, N. Y. (*Assoc. M., Mar. 6, 1901*)	Jan. 5, 1909
ENDICOTT, MORDECAI THOMAS. (*Past-President*). Civ. Engr., U. S. N.; Rear-Admiral (*Retired*), 1330 R St., N. W., Washington, D. C.	April 4, 1877
Endo, Tokichi. Chf., M. of W. and Works Section, Western Div. Supt. Office, Imperial Govt. Rys., Kobe, Japan	Feb. 1, 1905
Eno, Frank Harvey. Prof. of Municipal Eng., Ohio State Univ., Columbus, Ohio	Mar. 4, 1903
Ensign, Guert William. Eng.-Contr., Camp Hill, Pa. (*Assoc. M., Nov. 4, 1908*)	Sept. 6, 1910
Enzian, Charles. Min. Engr., U. S. Bureau of Mines (Res., 375 South River St.), Wilkes-Barre, Pa. (*Jun., Sept. 3, 1901; Assoc. M., Mar. 1, 1905*)	June 6, 1911
Ericson, John Ernst. City Engr.; Chairman, Chicago Subway Comm., 402 City Hall, Chicago, Ill.	May 7, 1902
Erlandsen, Oscar. Pres., Metropolis Eng. Co., 359 Fulton St., Jamaica, N. Y. (*Jun., May 1, 1889; Assoc. M., Dec. 2, 1891*)	Oct. 7, 1896
Ernst, Oswald Herbert. Brig.-Gen., U. S. A. (*Retired*); Chairman, Am. Section, International Waterways Comm., Westory Bldg., Washington, D. C.	July 4, 1888
Esselstyn, Horace Hovey. Engr., Westinghouse, Church, Kerr & Co., 274 Vinewood Ave., Detroit, Mich.	June 3, 1908
Estep, Josiah Madison. Asst. Chf. Engr., Dept. of Public Service, Cleveland, Ohio	Mar. 1, 1910
Evans, Edwin George. 410 Quebec Bank Bldg., Montreal, Que., Canada	July 10, 1907
Evans, Louis Hyde. Cons. Engr., 1333 Peoples Gas Bldg., Chicago, Ill.	July 3, 1889
Evans, Richard. 358 Fulton St., Jamaica, N. Y.	June 7, 1893

		Date of Membership
	Evans, Robert Rogers. 24 Arlington St., Haverhill, Mass.	July 1, 1909
	Ewen, John Meiggs. Cons. Engr., 740 Rookery Bldg., Chicago, Ill.	June 3, 1903
	Ewing, William Wallace. Engr., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City (Res., 426 Lenox Ave., Westfield, N. J.)	Oct. 7, 1908
	Fairchild, Samuel Edwards, Jr. Pres., Crusekemper Co., 530 Land Title Bldg., Philadelphia, Pa. *(Assoc. M., Dec. 7, 1904)*	Oct. 6, 1908
	Fairleigh, James Andrew. Secy. and Treas., Cushman-Fairleigh Eng. Co., 724 James Bldg., Chattanooga, Tenn.	Sept. 2, 1891
	Falk, Myron Samuel. Cons. Engr., 30 Church St. (Res., 44 West 53d St.), New York City. *(Jun., Feb. 4, 1902; Assoc. M., Oct. 4, 1905)*	April 6, 1909
	Fargo, William Gilbert. Civ. and Hydr. Engr., 303 Commonwealth Bldg., Jackson, Mich.	April 1, 1908
	Farley, Godfrey Pearson. Cons. Engr., 319 Church St., Richmond Hill, N. Y.	June 6, 1900
	Farley, John Moyer. Cons. Engr., 527 Fifth Ave., New York City. *(Jun., Dec. 5, 1888; Assoc. M., July 1, 1891)*	Sept. 1, 1897
	Farley, Philip Patrick. Pres., Jamaica Bay Impvt. Comm., 180 Montague St. (Res., 194 McDonough St.), Brooklyn, N. Y. *(Jun., Oct. 31, 1893; Assoc. M., Mar. 6, 1901)*	Feb. 1, 1910
	Farnham, Robert, Jr. Asst. Engr., P. R. R., Broad St. Station, Philadelphia, Pa. *(Assoc. M., July 9, 1906)*	April 5, 1910
	Farnum, Henry Harrison. 150 East 150th St., New York City	July 1, 1891
	Farnum, Loring Nelson. Care, Central Aguirre Sugar Co., 129 Front St., New York City	Dec. 4, 1907
	Farrar, Hartwell Prentice. Cons. Engr.; Chf. Engr., Birmingham & North Western Ry., Jackson, Tenn.	Nov. 1, 1893
	Farrington, Harvey. Cons. and Contr. Engr., 45 Broadway, New York City. *(Jun., June 19, 1891; Assoc. M., Feb. 6, 1895)*	Oct. 1, 1902
	Farrington, William Rowe. Div. Engr., Massachusetts Highway Comm., 10 Bank Bldg., Middleboro, Mass.	May 2, 1911
	Fauntleroy, James Dearing. Care, U. S. Reclamation Service, Elephant Butte, N. Mex.	June 5, 1907
	Fay, Edward Bayrd. Cons. Engr., (Brenneke & Fay), 1200 Fullerton Bldg., St. Louis, Mo. *(Assoc. M., Jan. 8, 1902)*	Jan. 2, 1906
	Fay, Frederic Harold. Div. Engr., Bridge and Ferry Div., Public Works Dept., 60 City Hall, Boston, Mass. *(Jun., Oct. 2, 1894; Assoc. M., April 2, 1902)*	Jan. 5, 1904
	Fehr, Harrison Robert. Pres. and Gen. Mgr., Easton Transit Co., Easton, Pa.	Oct. 5, 1898
	Fellows, Abraham Lincoln. Secy. and Gen. Mgr., The Field, Fellows & Hinderlider Eng. Co., 435 Century Bldg., Denver, Colo.	June 6, 1911
	Felt, Charles Frederick Wilson. Chf. Engr., A., T. & S. F. Ry., Topeka, Kans.	Mar. 3, 1897
	Feltham, Percy Marshall. Greenville, S. C.	July 1, 1908
	Felton, Burton Rogers. Treas., C. E. Trumbull Co., Engrs. and Contrs., Tremont Bldg., Boston, Mass. *(Assoc. M., April 4, 1894)*	Oct. 7, 1896
	Felton, Herbert Clark. Supt., Del. River Ferry Co. of N. J. of P. & R. Ry. System, Camden, N. J.	June 1, 1887
	Felton, Samuel Morse. Pres., C., G. W. R. R., Chicago, Ill.	Jan. 4, 1882
	Fendall, Benjamin Truman. Cons. Engr., 1417 Fidelity Bldg., Baltimore, Md.	May 7, 1902
N.	Fenkell, George Harrison. Civ. Engr. to Water Commrs. (Res., 334 Field Ave.), Detroit, Mich. *(Jun., Jan. 3, 1899; Assoc. M., Oct. 1, 1902)*	July 1, 1909
	Fenn, Robert Willson. Mgr., Mfg. Dept., Union Oil Co. of California, Room 229, Mills Bldg., San Francisco, Cal. *(Assoc. M., July 10, 1907)*.	Sept. 1, 1908
	Fenn, William Henry. 1000 Broome St., Wilmington, Del.	July 1, 1909
	Ferguson, George Robert. Asst. Engr., Dept. of Bridges, 179 Washington St., Brooklyn, N. Y.	Dec. 3, 1902
	Ferguson, Hardy Smith. Cons. Engr., 200 Fifth Ave., New York City. *(Assoc. M., Mar. 3, 1897)*	May 1, 1901
	Ferguson, James Easton. Operating Engr., The Toledo Bridge & Crane Co., 2721 Glenwood Ave., Toledo, Ohio. *(Assoc. M., June 1, 1904)*	Jan. 3, 1911
	Ferguson, John Berton. Civ. and Mech. Engr., Hagerstown, Md.	July 1, 1909
	Ferguson, John Neil. Asst. Engr., Massachusetts Board of Harbor and Land Commrs., Room 131, State House, Boston, Mass. *(Assoc. M., Oct. 2, 1901)*	May 5, 1908
	Ferguson, John William. Engr. and Bldg. Contr., 152 Market St., Paterson, N. J. *(Jun., Jan. 5, 1881)*	Feb. 2, 1887
	Fernald, Clarence Thayer. First Asst. Engr., Elev. and Subway Constr., Bost. Elev. Ry., 32 Malvern St., Melrose, Mass.	Oct. 7, 1908
	Fernstrom, Henning. Chf. Engr., The Virginian Ry., Norfolk, Va.	May 7, 1902
	Ferry, Charles Addison. With A. B. Hill, Cons. Civ. Engr., 24 Edgewood Ave., New Haven, Conn. *(Jun., May 4, 1881)*	Jan. 2, 1889

		Date of Membership
	Fessenden, Ralph Seth. Chf. Engr., Twin Falls-Raft River Land & Water Co., Rupert, Idaho	May 2, 1911
	Fetherston, John Turney. Engr.-in-Chg., Bureau of Street Cleaning, Borough of Richmond, New York City (Res., 16 Lenox Pl., New Brighton, N. Y.). *(Assoc. M., June 3, 1903)*	Oct. 5, 1909
	Fickes, Clark Robinson. Bridge Dept., C., B. & Q. R. R., 226 West Adams St., Chicago, Ill	Nov. 7, 1906
	Fickes, Edwin Stanton. In Chg., Eng., Min., Purchasing and Traffic Depts., Aluminum Co. of America, Pittsburgh, Pa. *(Jun., Jan. 4, 1898; Assoc. M., Feb. 6, 1901)*	Dec. 6, 1904
	Fieberger, Gustave Joseph. Lt.-Col., Corps of Engrs., U. S. A.; Prof. of Eng., West Point, N. Y	Oct. 2, 1895
	Field, Frederick Elbert. Res. Engr., Montreal Filtration Works, Montreal, Que., Canada. *(Assoc. M., Oct. 7, 1903)*	Sept. 6, 1910
	Field, George Russell. Care, Claremont Country Club, Oakland, Cal	Nov. 6, 1907
	Field, George Spencer. 452 Delaware Ave., Buffalo, N. Y	April 7, 1880
	Field, John Ellis. 435 Century Bldg., Denver, Colo	July 1, 1908
	Field, William Pierson. 976 Broad St., Newark, N. J. *(Jun., Dec. 7, 1887)*	Mar. 6, 1901
	Fields, Samuel James. 632 Ellicott St., Buffalo, N. Y	Mar. 5, 1884
	Filley, Oliver Dwight. Superv. Engr., Bureau of Public Works, Philippine Islands, Manila, Philippine Islands	April 5, 1910
	Fink, Rudolph. St. Matthews, Ky	Sept. 21, 1870
	Finley, Edwin Clifford. Chf. Engr., Mfrs. Ry., South Side Bank Bldg., St. Louis, Mo. *(Assoc. M., April 5, 1905)*	Nov. 30, 1909
	Finley, William Henry. Asst. Chf. Engr., C. & N. W. Ry., Batavia, Ill.	Feb. 4, 1903
	Firmstone, Frank. Easton, Pa	Aug. 7. 1878
	Fish, John Charles Lounsbury. Prof., R. R. Eng., Stanford Univ., Box 233, Stanford University, Cal. *(Jun., Jan. 31, 1893; Assoc. M., Feb. 7, 1900)*	Oct. 6, 1908
	Fisher, Edwin Augustus. City Engr., 30 Albemarle St., Rochester, N. Y.	July 4, 1888
	Fisher, Francis Davis. Engr. in Chg., Degnon Cape Cod Canal Constr. Co., Sandwich, Mass	May 2, 1888
	Fisher, Janon. Eccleston, Md. *(Assoc. M., May 4, 1892)*	Jan. 5, 1898
	Fisher, Samuel Brownlee. Chf. Engr., Mo., Kans. & Tex. Ry., 407 Wainwright Bldg., St. Louis, Mo	Oct. 7, 1903
	Fisk, Walter Leslie. Col., Corps of Engrs., U. S. A.; Pres., Mississippi River Comm., 1322 Liggett Bldg., St. Louis, Mo	April 1, 1896
	Fitch, Asa Betts. 415 Hollywood Boulevard, Hollywood Station, Los Angeles, Cal	Mar. 5, 1884
	Fitch, Charles Hall. Project Engr., U. S. Reclamation Service, Phœnix, Ariz	June 5, 1901
	Fitch, Charles Lincoln. 253 Throop Ave., Brooklyn, N. Y	Oct. 2, 1901
	Fitch, Graham Denby. Lt.-Col., Corps of Engrs., U. S. A., U. S. Engr. Office, Montgomery, Ala	Feb. 4, 1903
	Fitch, Howard Augustus. Pres., Kansas City Structural Steel Co., 1012 Baltimore Ave., Kansas City, Mo	July 9, 1906
	FitzGerald, Christopher Columbus. Engr., T. L. Huston Contr. Co., Habana 88, Havana, Cuba. *(Assoc. M., Oct. 2, 1901)*	June 30, 1911
N. N.	FITZGERALD, DESMOND. *(Past-President)*. Cons. Hydr. Engr., Brookline, Mass	Sept. 3, 1884
	FitzGerald, John Leland. 147 Jay St., Schenectady, N. Y	Jan. 2, 1889
	Flad, Edward. Cons. Engr., 1200 Fullerton Bldg., St. Louis, Mo. *(Jun., Jan. 7, 1885)*	Feb. 1, 1888
	Flagg, Josiah Foster. 2001 Anacapa St., Santa Barbara, Cal	Oct. 7, 1874
	Fleming, Harvey Brown. Chf. Engr., Chicago City Ry., 1640 First National Bank Bldg., Chicago, Ill	Mar. 4, 1908
	Fleming, *Sir* Sandford. Ottawa, Ont., Canada	Sept. 18, 1872
	Fletcher, Austin Bradstreet. Highway Engr., California Highway Comm., Forum Bldg., Sacramento, Cal	June 1, 1909
	Fletcher, Robert. Prof. of Civ. Eng. and Director of Thayer School of Civ. Eng., Dartmouth Coll., Hanover, N. H. *(Assoc., Nov. 4, 1874)*	Aug. 31, 1909
	Flinn, Alfred Douglas. Dept. Engr., Board of Water Supply, 165 Broadway, New York City (Res., Glenbrook Ave., Park Hill, Yonkers, N. Y.). *(Assoc. M., Dec. 6, 1899)*	May 2, 1905
	Floesch, Jacob Martin. Engr. and Contr., 515 German Insurance Co. Bldg., Rochester, N. Y	Jan. 4, 1905
	Floy, Henry. Cons. Engr., 165 Broadway, New York City	June 6, 1911
	Flynn, John, Jr. Civ. and Elec. Engr., 62 Congress St., Troy, N. Y. *(Assoc. M., Jan. 8, 1902)*	May 2, 1905
	Follett, William W. U. S. Cons. Engr., International Boundary Comm., United States and Mexico, El Paso, Tex	July 5, 1893
	Folwell, Amory Prescott. Editor, *Municipal Journal and Engineer,* 239 West 39th St., New York City. *(Jun., Feb. 5, 1890; Assoc. M., June 7, 1893)*	Nov. 3, 1897

		Date of Membership
	FOOTE, ARTHUR DeWINT. (*Director*). Gen. Mgr., North Star Mines Co., Grass Valley, Cal.	May 7, 1884
	FORCE, CYRUS GILDERSLEEVE. Cons. Engr., Flanders, Morris Co., N. J.	Feb. 6, 1878
	FORD, FREDERICK LUTHER. (Ford, Buck & Sheldon), 60 Prospect St., Hartford, Conn. (*Assoc. M., Oct. 1, 1902*)	Oct. 31, 1905
	FORD, PORTER DWIGHT. 601 West 168th St., New York City	Jan. 4, 1905
	FORD, THEODORE BOYDEN. 946 Main St., Bridgeport, Conn.	Dec. 6, 1905
	FORD, WILLIAM GRIFFING. Cons. Engr., 190 Montague St., Brooklyn, N. Y.	Oct. 5, 1904
	FORD, WILLIAM HAYDEN. Cons. Engr., 1124 Arcade Bldg., Philadelphia, Pa. (*Jun., Nov. 5, 1895; Assoc. M., June 3, 1903*)	Sept. 1, 1908
	FORGIE, JAMES. Cons. Engr. (Jacobs & Davies), 30 Church St., New York City	Oct. 5, 1904
	FORSYTH, ROBERT. Cons. Engr., 1159 The Rookery, Chicago, Ill.	May 12, 1875
	FORT, EDWIN JOHN. Chf. Engr. of Sewers, 1014 Mechanics Bank Bldg., Brooklyn, N. Y. (*Assoc. M., April 1, 1896*)	Nov. 1, 1904
	FORTIN, SIFROY JOSEPH. Representing Milliken Bros., Apartado 1244, City of Mexico, Mexico. (*Assoc. M., Nov. 6, 1895*)	Dec. 6, 1904
	FOSS, FRED EUGENE. Prof., Civ. Eng., Cooper Union, New York City	April 1, 1903
	FOSS, WILLIAM EVERETT. Div. Engr., Met. Water-Works, 1 Ashburton Pl., Boston, Mass.	Mar. 4, 1908
	FOSTER, ERNEST HOWARD. Vice-Pres., Power Specialty Co., 111 Broadway, New York City	May 6, 1903
	FOSTER, FRANK. Engr.-in-Chf., Buenos Aires Western Ry., Estacion Once, Buenos Aires, Argentine Republic	June 30, 1911
	FOSTER, ROBERT ARNOLD. Acting Gen. Mgr., Lewiston-Clarkston Impvt. Co., Clarkston, Wash.	Oct. 31, 1911
	FOSTER, WILBUR FISK. 1702 West End Ave., Nashville, Tenn.	May 7, 1873
	FOUQUET, JOHN DOUGLAS. Fishkill, N. Y.	June 3, 1885
	FOWLER, CHARLES EVAN. Pres. and Chf. Engr., International Contract Co. and International Dredging Co., 501 Central Bldg., Seattle, Wash. (*Jun., May 7, 1890; Assoc. M., Dec. 6, 1893*)	May 3, 1898
	FOWLER, THOMAS WALKER. Civ., Mech. and Elec. Engr., 421 Collins St., Melbourne, Victoria, Australia	Dec. 2, 1903
	FOX, HENRY. Chf. Engr., Maryland Dredging & Contr. Co. and Furst Clark Dredging Co. (Res., 2305 Elsinore Ave.), Baltimore, Md.	July 1, 1909
	FOX, JOHN ANGELL. Commr. at Large, Panama-California Exposition, San Diego, Cal.	Feb. 2, 1909
	FOX, STEPHENSON WATERS. Cons. Engr., 424 Rialto Bldg., Kansas City, Mo. (*Jun., July 7, 1880*)	Oct. 6, 1886
	FRANCIS, CHARLES. 8 Masonic Temple, Davenport, Iowa	May 4, 1892
R.	**FRANCIS, GEORGE BLINN.** Cons. Engr., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City. (*Jun., Sept. 5, 1883*)	Nov. 7, 1888
	FRANCIS, HENRY NEWTON. Arlington, R. I. (*Jun., Mar. 1, 1876*)	Nov. 7, 1888
	FRANCIS, WALTER JOSEPH. Cons. Engr., Walter J. Francis & Co., 232 St. James St., Montreal, Que., Canada. (*Assoc. M., May 1, 1901*)	April 5, 1904
	FRANCISCO, FERRIS LEROY. Chf. Engr., The Am. Tobacco Co., 111 Fifth Ave., Room 1008, New York City	Dec. 5, 1911
	FRANKLIN, BENJAMIN. Civ. and Cons. Engr. (Franklin & Clarke), 906 Crozer Bldg., Philadelphia, Pa. (*Assoc. M., April 1, 1903*)	June 5, 1906
	FRASER, CHARLES EDWARD. (Fraser, Brace & Co.), 1328 Broadway, New York City. (*Jun., June 4, 1901; Assoc. M., Sept. 2, 1903*)	June 2, 1908
	FRAZIER, HARRY. Cons. Engr., 812 Am. National Bank Bldg., Richmond, Va.	May 1, 1889
	FRAZIER, JAMES LEWIS. 808 Columbia Bldg., Louisville, Ky.	Sept. 1, 1880
	FRAZIER, JAMES WELCH. Rockefeller Bldg., Cleveland, Ohio. (*Assoc. M., May 6, 1903*)	Sept. 5, 1905
	FREDERICKSON, JOHN HENRY. Mgr., Western Office, James Stewart & Co., Denver, Colo.	Nov. 1, 1910
	FREELAND, CHESTER SHEPARD. Chf. Engr., Porterville Northeastern Ry., Porterville, Tulare Co., Cal.	Jan. 3, 1906
N. N.	**FREEMAN, JOHN RIPLEY.** Consulting Hydraulic Engr.; also Pres., Manufacturers Mutual Fire Insurance Co., 815 Banigan Bldg., Providence, R. I. (*Jun., June 7, 1882*)	April 3, 1889
	FRENCH, ALEXIS HENRY. Town Engr., Town Hall, Brookline, Mass.	June 6, 1894
	FRENCH, ARTHUR WILLARD. Prof. of Civ. Eng., Worcester Polytechnic Inst., Worcester, Mass. (*Assoc. M., April 4, 1900*)	Dec. 6, 1904
	FRENCH, FRANK CHAUNCEY. Cons. Engr., 427 Newhouse Bldg., Salt Lake City, Utah. (*Assoc. M., Dec. 3, 1902*)	Feb. 4, 1908
	FRENCH, JAMES ADAMS. Engr., U. S. Reclamation Service, El Paso, Tex.	July 1, 1909
	FRENCH, JAMES BENTON. Cons. Engr., 50 Church St., Room 1276, New York City. (*Jun., Feb. 6, 1889; Assoc. M., Feb. 7, 1894*)	Nov. 2, 1898
	FRENCH, MANSFIELD JOSEPH. Engr., M. of W., Utica & Mohawk Val. Ry. and Oneida Ry., Electric Ry. Bldg. (Res., 906 Sunset Ave.), Utica, N. Y. (*Assoc. M., July 9, 1906*)	Sept. 5, 1911
	FRENCH, OWEN BERT. Asst., Coast and Geodetic Survey, Washington, D. C.	April 1, 1903

	Date of Membership
Frew, Archibald Smith. Engr. in Chg., Almaden-Etheridge Ry., Charleston, North Queensland, Australia	Oct. 3, 1900
Freyhold, Felix. 236 First St., S. E., Washington, D. C. (*Assoc. M., Sept. 2, 1891*)	April 2, 1902
Fries, Amos Alfred. Capt., Corps of Engrs., U. S. A.; Director of Military Eng., U. S. Engr. School, Washington Barracks, D. C.	Oct. 3, 1911
Frink, Ellis Alexander. Bridge Engr., S. A. L. Ry., Portsmouth, Va. (*Assoc. M., June 6, 1900*)	Dec. 4, 1901
Fritch, Louis Charlton. 5119 Kimbark Ave., Chicago, Ill.	Oct. 3, 1900
Fritz, John. 155 Market St., Bethlehem, Pa. (*Hon. M., Sept. 5, 1899*)	July 5, 1893
Fry, Alfred Brooks. Chf. Engr., U. S. Treasury Service; Member of Board of Cons. Engrs., Impvt., State Canals, U. S. Custom House Bldg., New York City	Dec. 6, 1910
Frye, Albert Irvin. Civ. and Cons. Engr., 90 West St., New York City	Dec. 2, 1896
Fuertes, James Hillhouse. Hydr and San. Engr., 140 Nassau St., New York City. (*Jun., May 2, 1888*)	Feb. 6, 1895
Fuller, Almon Homer. Prof. of Civ. Eng. and Dean, Coll. of Eng., Univ. of Washington, 5208 Fourteenth Ave., N. E., Seattle, Wash. (*Jun., April 4, 1899; Assoc., Feb. 4, 1902*)	May 3, 1910
Fuller, Frank Louis. 12 Pearl St., Room 34, Boston, Mass. (*Jun., April 4, 1883*)	April 4, 1888
Fuller, Franklin Ide. Vice-Pres., Portland Ry., Light & Power Co., Electric Bldg., Portland, Ore.	Jan. 6, 1886
R. Fuller, George Warren. Hydr. and San. Engr. (Hering & Fuller), 170 Broadway, New York City. (*Assoc. M., Mar. 1, 1899*)	May 31, 1904
Fuller, Harry. Chf. Engr., King Bridge Co., Cleveland, Ohio	Sept. 7, 1904
Fuller, William Barnard. Chf. Engr., Mexican Northern Power Co., Santa Rosalia, Chihuahua, Mexico. (*Jun., June 3, 1885*)	May 1, 1895
Fulton, James Edward. Civ. and Mech. Engr., 155 The Terrace, Wellington, New Zealand	Oct. 4, 1910
Fulton, John Addison. 934 West Sixth St., Los Angeles, Cal.	May 4, 1887
Furber, William Copeland. Archt. and Cons. Engr., 418 Walnut St., Philadelphia, Pa.	May 2, 1899
Furman, Job Rockfield. Chf. Mech. Engr., D. H. Burnham & Co., Chicago, Ill. (*Jun., July 2, 1890*)	Dec. 7, 1904
Fyfe, James Lincoln. Structural Engr., 17 Van Buren St., 907, Chicago, Ill.	Oct. 5, 1904
Gadd, Robert Foster. New England Mgr., Levering & Garrigues Co., Steel Contrs., Connecticut Mutual Bldg., Hartford, Conn.	Sept. 6, 1910
Gadsden, George Morrall. Pres. of The Gadsden Contr. Co., Savannah, Ga.	May 4, 1898
Gagel, Edward. Chf. Engr., N. Y., N. H. & H. R. R. (Res., 323 Center St.), West Haven, Conn.	April 3, 1907
Gahagan, Walter Hamer. Contr. Engr., 189 Montague St., Brooklyn, N. Y. (*Jun., Sept. 5, 1888; Assoc. M., July 1, 1891*)	April 3, 1901
Galloway, John Debo. (Galloway & Markwart), First National Bank Bldg., San Francisco, Cal.	Dec. 6, 1905
Gamble, Francis Clarke. Chf. Engr. and Insp. of Railways, British Columbia, Victoria, B. C., Canada	April 1, 1891
Gardiner, Frederick William. Prin. Asst. Engr., Interborough Rap. Trans. Co., Manhattan Ry. Div., 32 Park Pl., New York City. (*Assoc. M., Dec. 6, 1899*)	Nov. 2, 1908
Gardiner, John Peden. 226 Laughlin Bldg., Los Angeles, Cal. (*Assoc. M., Mar. 7, 1906*)	Sept. 6, 1910
Gardner, Edmund LeBreton. Pres., Jersey City Water Supply Co., 158 Ellison St., Paterson, N. J.	June 7, 1882
Gardner, Martin Luther. Asst. Engr., P. R. R., Jersey City (Res., 66 Milford Ave., Newark), N. J. (*Assoc. M., Sept. 2, 1891*)	Mar. 4, 1896
Gardner, William Montgomery. P. O. Box 1027, Care, U. S. Engr.'s Office, Memphis, Tenn.	Dec. 7, 1904
Garlinghouse, Frederick Leman. Glenshaw, Pa.	Mar. 7, 1906
Garrett, James Edwin. Asst. Mgr., Min. Dept., Cia M., F. y A. "Monterey" S. A., Apartado No. 283, Monterey, N. L., Mexico	April 5, 1905
Garrett, John Thomas. Pres., Missouri Bridge & Iron Co., 1000 Fullerton Bldg., St. Louis, Mo. (*Assoc. M., May 1, 1901*)	Sept. 6, 1910
Garrett, Robert Peel. Vice-Pres. and Treas., Missouri Bridge & Iron Co., 1000 Fullerton Bldg., St. Louis, Mo. (*Jun., Jan. 4, 1898; Assoc. M., Oct. 2, 1901*)	Mar. 5, 1907
Garrison, Everett. Cons. Engr., Newburgh, N. Y.	Mar. 7, 1894
Garrison, Frank Lynwood. Min. Engr., 766 Drexel Bldg., Philadelphia, Pa. (*Assoc. M., Sept. 7, 1892*)	Mar. 5, 1907
Gaston, Louis Prevost. (Richards & Gaston), 143 Liberty St., New York City	Feb. 1, 1905

	Date of Membership
Gates, Christopher Lawrence. Cons. Engr., 416 Irving St., Toledo, Ohio. (*Jun., Dec. 4, 1878*)	Sept. 5, 1883
Gates, Horace Delphos. Asst. in Office of City Engr., City Engr.'s Office, San Francisco, Cal	Mar. 7, 1883
Gault, Homer Johnston. Constr. Engr., U. S. Reclamation Service, Elephant Butte, N. Mex	Oct. 2, 1907
Gaut, Robert Eugene. With Leonard Constr. Co., 1937 McCormick Bldg., Chicago, Ill	April 3, 1907
Gay, Charles Webster. 25 Exchange St., Lynn, Mass	May 6, 1891
Gay, Martin. Asst. Engr., Dept. of Bridges, City of New York, 179 Washington St., Brooklyn, N. Y. (Res., 169 East 80th St., New York City. (*Jun., June 4, 1884*)	June 5, 1889
Gayler, Carl. 900 Wainwright Bldg., St. Louis, Mo	Sept. 3, 1884
Gayler, Ernest Rotteck. Civ. Engr., U. S. N., Naval Station, Pearl Harbor, Hawaii. (*Assoc. M., April 6, 1904*)	June 30, 1911
Gayol, Roberto. Cons. Engr.; Chf. Engr. of the Sauteña Irrig. Works, P. O. Box 766, City of Mexico, Mexico	Mar. 2, 1892
Gazlay, Webster. Engr. and Vice-Pres., National Concrete Constr. Co., Board of Trade Bldg., Louisville, Ky	June 7, 1905
Geddes, Edmond Burns. U. S. Asst. Engr., Natchez, Miss	Mar. 2, 1898
Geddes, James Kennon. Gen. Mgr., Ohio River & West. Ry., Zanesville, Ohio	Jan. 2, 1890
Geer, Harvey Mosher. Ballston, N. Y	June 6, 1894
Gehler, Gustav Willy. Chf. Engr., Vice-Pres. and Mgr., Tech. Div. of Firm, Dyckerhoff & Widmann; Address, Kurfurstenstr. 1, Dresden, Germany	April 5, 1910
Gemmell, Robert Campbell. Asst. Gen. Mgr., Utah Copper Co., Ray Consolidated Copper Co., Chino Copper Co., and Bingham & Garfield Ry., McCornick Bldg., Salt Lake City, Utah. (*Assoc. M., Oct. 5, 1892*)	Dec. 4, 1895
George, James Zachariah. Pres., The George Co., Engrs., and The George Public Utility Co., 526 Randolph Bldg., Memphis, Tenn	Jan. 3, 1911
GERBER, EMIL. (*Director*). Asst. to Pres., Am. Bridge Co., Frick Bldg., Pittsburgh, Pa	Feb. 1, 1888
Gerig, William. Vice-Pres. and Chf. Engr., Pacific & Eastern Ry. and Cons. Hydr. Engr., Spokane, Portland & Seattle Ry., Medford, Ore	Mar. 5, 1902
Gerry, Martin Hughes, Jr. Chf. Engr. and Gen. Mgr., Missouri River Power Co., Helena, Mont. (*Assoc. M., June 6, 1900*)	Dec. 3, 1902
Gessner, Gustavus Adolphus, Jr. Cons. Engr. (Res., 2465 Scottwood Ave.), Toledo, Ohio. (*Assoc. M., April 2, 1902*)	Oct. 3, 1905
Gester, William Burr. Pacific Coast Representative, Robert W. Hunt & Co., 418 Montgomery St., San Francisco, Cal	Oct. 4, 1910
Getman, Frank Lawton. Cons. Engr. and Mfrs. Representative, 438 Lonja de Comercia, Havana, Cuba. (*Assoc. M. April 5, 1905*)	May 4, 1909
N. Gibbs, George. Cons. Engr.; Chf. Engr., Elec. Traction, L. I. R. R.; Cons. Engr., P. R. R., Pennsylvania Station, New York City	Mar. 6, 1895
Gibson, James Edwin. Prin. Asst. Engr., Am. Pipe & Constr. Co., 112 North Broad St., Philadelphia, Pa	Sept. 6, 1910
Gibson, Jasper Manlius. Secy. and Treas., Mulcahy & Gibson, Inc., 381 Fourth Ave., New York City	Feb. 6, 1912
Giddings, Frederick. Cons. Municipal Engr., Atchison, Kans	June 6, 1906
Gideon, Abraham. Supt., Water Supply and Sewers, City Hall, Manila, Philippine Islands. (*Assoc. M., Sept. 3, 1902*)	Nov. 1, 1910
Gifford, George Edwin. Secy., Bridge Builders' Soc., 50 Church St., New York City. (*Assoc. M., Oct. 7, 1891*)	Jan. 1, 1896
Gifford, Robert Ladd. Pres., Illinois Eng. Co., Chicago, Ill. (*Assoc. M., May 6, 1903*)	June 4, 1907
Giles, Robert. 59 West 45th St., New York City	May 6, 1891
Gilfillan, George Aiken. Cons. Engr., 341 Fourth Ave., Pittsburgh, Pa.	Dec. 6, 1905
Gillespie, Richard Henwood. Chf. Engr., Sewers and Highways, Bronx, 177th St. and Third Ave. (Res., 2774 Briggs Ave., Bedford Park), New York City. (*Assoc. M., Oct. 3, 1900*)	June 5, 1906
Gillette, Edward. Sheridan, Wyo	July 3, 1889
Gillette, Halbert Powers. Editor, *Engineering-Contracting*, 537 South Dearborn St., Chicago, Ill	May 4, 1904
Gillette, Lewis Singer. Pres., Elec. Steel Elevator Co., Minneapolis, Minn	June 7, 1899
Gilman, James Beatty. Chf. Engr., Minneapolis Steel & Machinery Co., Minneapolis, Minn	Oct. 7, 1908
Gladding, Henry Holbrook. Asst. City Engr., 30 Stanley St., New Haven, Conn. (*Jun., July 1, 1885*)	Jan. 4, 1888
Glasgow, Arthur Graham. (Humphreys & Glasgow), 38 Victoria St., Westminster, London, England	Jan. 3, 1900
Glazier, William Leonard. Cons. Engr., Parish Bldg., Newport, Ky. (*Assoc. M., Oct. 7, 1903*)	Mar. 5, 1907
Goddard, Leslie Warren. Prin. Asst. Engr., U. S. Engr. Office, Grand Rapids, Mich. (*Assoc. M., Mar. 2, 1892*)	Oct. 6, 1908

		Date of Membership
	Godfrey, Edward. Structural Engr. (Robert W. Hunt & Co.), Monongahela Bank Bldg., Pittsburgh, Pa.	Oct. 5, 1909
	Goethals, George Washington. Chairman and Chf. Engr., Isthmian Canal Comm., Culebra, Canal Zone, Panama	Mar. 1, 1910
	Going, Alvah Seymour. Locating Engr., G. T. Ry. System, 407 G. T. Ry. Bldg., Montreal, Que., Canada. *(Assoc. M., May 4, 1892)*	June 7, 1899
R.	Goldmark, Henry. Desgning Engr., Isthmian Canal Comm., Culebra, Canal Zone, Panama. *(Jun., May 7, 1884)*	June 6, 1888
	Goodale, Loomis Farrington. Superv. Railway Expert to the Govt. of the Philippine Islands, Manila, Philippine Islands	Nov. 7, 1900
	Goodnough, Xanthus Henry. Chf. Engr., State Board of Health, Room 140, State House, Boston, Mass. *(Assoc. M., May 6, 1896)*	June 4, 1902
C.	Goodrich, Ernest Payson. Cons. Engr., 35 Nassau St., New York City. *(Jun., April 3, 1900)*	Nov. 1, 1905
	Goodrich, Wilbur Francis. Cons. Engr., 10 Gibbens St., Somerville, Mass.	May 4, 1887
	Goodwin, George Estyn. Supt., Dalles-Celilo Canal, U. S. Engrs., War Dept., The Dalles, Ore. *(Assoc. M., Jan. 8, 1908)*	July 1, 1909
	Goodwin, James Bowman. Asst. Gen. Mgr., Mount Hood Ry. & Power Co., 550 Tilamook St., Portland, Ore	Dec. 4, 1907
	Gordon, Charles Edward. Care, Dept. of Public Works, Manila, Philippine Islands	Sept. 6, 1905
	Gotshall, William Charles. 1 West 72d St., New York City	May 7, 1902
	Gould, Harry Madera. Vice-Pres. and Gen. Mgr., Foster-Creighton-Gould Co., Engrs. and Gen. Contrs., 3 Berry Blk., Nashville, Tenn.	Nov. 30, 1909
	Gould, William Tillotson. Expert Aid, Public Works Dept., U. S. N., in Chg. of Dry Dock No. 4, Navy Yard, Brooklyn, N. Y.	Jan. 2, 1890
	Gove, William Granville. Supt. of Equipment, Brooklyn Rapid Transit System, 85 Clinton St., Brooklyn, N. Y. *(Assoc. M., Feb. 3, 1904)*	Feb. 1, 1910
	Govern, Edward James. Div. Engr., Western Div., State of New York, 939 Granite Bldg., Rochester, N. Y.	Jan. 8, 1908
	Grace, Arthur M. Chf. Engr., Southern Alberta Land Co., Ltd., Medicine Hat, Alta., Canada	July 1, 1909
	Grady, Charles Benedict. Asst. Mech. Engr., New York Edison Co., 55 Duane St., New York City. *(Assoc. M., Sept. 6, 1905)*	Aug. 31, 1909
	Grafton, Charles Edwin. New Cumberland, W. Va.	Jan. 1, 1896
	Graham, Charles Hallett. Chf. Engr. in Chg. of Sewers, Borough of Manhattan, 21 Park Row, New York City	Sept. 7, 1887
	Granbery, Julian Hastings. 145 Milton St., Brooklyn, N. Y. *(Jun., Sept. 6, 1898; Assoc. M., Sept. 2, 1903)*	April 6, 1909
	Grant, Emerson Warren. Asst. Engr., A., T. & S. F. Ry., 24th St. and Topeka Ave., Topeka, Kans.	Dec. 4, 1889
	Grant, Justus Herbert. Contr. Engr., 78 South Goodman St., Rochester, N. Y.	Mar. 2, 1892
	Grant, William. (Grant & Letton), 401 F. & M. Bldg., Lincoln, Nebr.	Feb. 1, 1910
	Grantham, Herbert Thomas. Chf. Engr., Belmont Iron Works, 1622 Real Estate Trust Bldg., Philadelphia, Pa. *(Assoc. M., Feb. 5, 1896)*	May 7, 1902
	Graves, Edwin Dwight. Address unknown. *(Assoc. M., Jan. 2, 1895)*	Dec. 2, 1896
	Graves, Walter Hayden. Box 298, Portland, Ore	Feb. 2, 1909
	Graves, Walter Joseph. U. S. Engr. Office, Sault Ste. Marie, Mich. *(Assoc. M., July 9, 1906)*	Jan. 4, 1910
	Gray, Edward. 718 Chemical Bldg., St. Louis, Mo. *(Assoc. M., May 1, 1907)*	Dec. 6, 1910
	Gray, George Edward. Cons. Engr., 2945 Magnolia St., Glenwood Park, Berkeley, Cal. *(Hon. M., June 5, 1894)*	July 2, 1873
	Gray, John Henry. Pres., J. H. Gray Co., 2019 Fuller Bldg., New York City	Oct. 2, 1895
	Gray, Samuel Merrill. Cons. Engr., 933 Banigan Bldg., Providence, R. I.	May 15, 1872
	Green, Bernard Lincoln. Vice-Pres., The Osborn Eng. Co., Osborn Bldg., Cleveland, Ohio	April 3, 1901
	Green, Bernard Richardson. Supt., Building and Grounds, Library of Congress, Washington, D. C.	Oct. 2, 1889
	Green, Hubert Edward. Res. Engr., Riverside Groves & Water Co., 631 Central Bldg., Los Angeles, Cal.	Dec. 2, 1903
	Green, Samuel Martin. Cons. Engr., 318 Main St., Springfield, Mass.	July 1, 1908
	Greene, Francis Vinton. 65 Pine St., New York City	June 3, 1885
	Greene, George Sears, Jr. Cons. Engr., 11 Broadway, New York City	Dec. 4, 1867
	Greene, Robert Maxson. Asst. Engr., Am. Bridge Co., Ambridge, Pa. *(Assoc. M., June 1, 1898)*	Sept. 1, 1908
	Greenfield, Robert Arthur. 185 Madison Ave., New York City	Oct. 4, 1910
R.	Gregory, John Herbert. Cons. Engr. (Rudolph Hering & John H. Gregory), 170 Broadway, New York City. *(Jun., Jan. 3, 1899; Assoc. M., April 3, 1901)*	Dec. 4, 1906
	Gregory, Luther Elwood. Civ. Engr., U. S. N., U. S. Navy Yard, Portsmouth, N. H.	April 6, 1904
	Gregory, William Benjamin. Prof. of Experimental Eng., Tulane Univ.; Irrig. Engr., U. S. Dept. of Agriculture, 630 Pine St., New Orleans, La.	Nov. 8, 1909

		Date of Membership
N.	Greiner, John Edwin. Cons. Engr., Fidelity Bldg., Baltimore, Md.	June 4, 1890
	Gresham, Robert Hall. Chf. Engr., Asherton & Gulf Ry., 724 West Poplar St., San Antonio, Tex.	May 4, 1898
	Griffin, William Reid Wesley. Gen. Mgr., Tri-State Ry. & Elec. Co., East Liverpool, Ohio	Feb. 5, 1908
	Griggs, Julian. Chf. Engr., Lancaster Traction & Power Co., 1318 Forsythe Ave., Columbus, Ohio	Oct. 4, 1899
	Grimes, Edwin Lincoln. Cons. Engr., 77 Maple Ave., Troy, N. Y.	Mar. 2, 1904
	Grimm, Carl Robert. Standish Arms, Brooklyn, N. Y.	June 4, 1890
	Grimshaw, James Walter. St. Stephen's Club, Westminster, London, S. W., England	Nov. 7, 1888
	Grossart, Lewis John Henry. Town Engr., Northampton and Catasauqua, Pa., Room 423, Commonwealth Bldg., Allentown, Pa.	May 1, 1907
	Grubb, Ernest. City Engr. to the Corporation of Grahamstown, P. O. Box 103, Grahamstown, South Africa	Jan. 31, 1911
N.	Grunsky, Carl Ewald. Pres., Am. Eng. Corporation, 515 Mechanics Inst. Bldg., San Francisco, Cal.	Oct. 5, 1898
	Gumaer, Edward Bennet. Allenhurst, N. J.	Sept. 6, 1905
	Gunn, William Edward. Middlesboro, Ky.	April 5, 1905
	Gunnell, William Covington. Cosmos Club, 1520 H St., N. W., Washington, D. C.	Feb. 7, 1877
	Guppy, Benjamin Wilder. Engr. of Structures, B. & M. R. R., Boston, Mass. (*Jun., June 19, 1891; Assoc. M., Oct. 3, 1894*)	Feb. 6, 1901
	Gutelius, Frederick Passmore. Gen. Supt., C. P. Ry., Montreal, Que., Canada.	Oct. 3, 1906
	Guthrie, Edward Buckingham. Chf. Engr., Grade Crossing Comm., 436 Ellicott Sq. (Res., 562 West Ferry St.), Buffalo, N. Y. (*Assoc., Sept. 3, 1884*)	Oct. 5, 1887

	Haas, Edward Francis. Merchants Exchange Bldg., San Francisco, Cal. (*Jun., Feb. 6, 1894; Assoc. M., Sept. 5, 1900*)	Feb. 6, 1906
	Hackney, John Wesley. (Ashmead & Hackney), 622 Bartlett Bldg., Atlantic City, N. J.	Oct. 5, 1909
	Hadsall, Harry Hugh. Gen. Supt., Leonard Constr. Co., Room 1937, McCormick Bldg., Chicago, Ill.	Mar. 6, 1907
	Haight, Horace De Remer. Engr. for Thos. Prosser & Son, 15 Gold St., New York City (Res., 1008 St. Johns Pl., Brooklyn, N. Y.). (*Jun., May 1, 1900; Assoc. M., Feb. 4, 1903*)	Jan. 31, 1911
	Haight, Stephen Samuel. Civ. Engr. and City Surv., 64 Buchanan Pl., University Heights, New York City	June 1, 1881
	Haines, Caspar Wistar. 322 Arcade Bldg., Philadelphia, Pa. (*Jun., Feb. 2, 1876*)	Oct. 7, 1891
	Haines, Eugene Grove. Asst. Engr., Public Service Comm., First Dist., New York City, 23 Flatbush Ave., Brooklyn, N. Y. (*Assoc. M., May 1, 1901*)	April 5, 1910
	Haines, Henry Stevens. Villa Gascoyne, Alassio, Italy	Nov. 2, 1887
	Hains, Peter Conover. Brig.-Gen., U. S. A. (*Retired*); Cons. and Civ. Engr., Union Trust Bldg., Washington, D. C.	April 2, 1890
	Hale, Richard Augustus. Prin. Asst. Engr., Essex Co., Lawrence, Mass. (*Jun., Feb. 6, 1884*)	July 1, 1891
	Hall, Benjamin Mortimer. Cons. Engr., Peters Bldg., Atlanta, Ga.	Feb. 6, 1901
	Hall, Henry Arthur. Palmer, Wash.	May 7, 1902
	Hall, John Lincoln. Second Vice-Pres., Purdy & Henderson, 1142 Henry Bldg., Seattle, Wash.	July 10, 1907
	Hall, Julien Astin. Cons. Engr., Wenonda, Pittsylvania Co., Va.	June 5, 1889
N.	Hall, William Hammond. Cons. Engr., 324 Haight St., San Francisco, Cal.	Jan. 2, 1884
	Hall, William McLaurine. Union Trust Bldg., Parkersburg, W. Va.	Dec. 6, 1893
	Hallihan, John Philip. Care, Chas. B. Eddy, 55 Liberty St., New York City. (*Assoc. M., April 4, 1900*)	June 5, 1906
	Hallock, James Currie. Deputy Chf. Engr., Dept. of Public Works, City Hall, Newark, N. J.	Oct. 3, 1906
	Hallsted, James Cottle. Cons. Engr., 1121 The Rookery, Chicago, Ill.	Jan. 4, 1905
	Ham, William Hale. Cons. Engr., Albany Bldg., Boston, Mass. (*Assoc. M., Nov. 5, 1902*)	Sept. 3, 1907
	Hambleton, Francis Henry. Cons. Engr., Consolidated Gas Co., Baltimore, Md.	Mar. 5, 1873
	Hamilton, Frank Henry. Commr. of Public Works, Springfield, Ill.	June 30, 1910
	Hamilton, John Wilson. Engr. and Contr. (Hamilton & Chambers), 29 Broadway, New York City	July 10, 1907
	Hamilton, William Gaston. 105 East 21st St., New York City	Oct. 7, 1868
	Hamlin, George Herbert. Bangor, Me.	July 3, 1895
	Hamlin, Homer. City Engr., Los Angeles, Cal.	May 4, 1904
	Hammatt, Edward Augustus White. Cons. Engr., Hyde Park, Mass.	June 5, 1901

	Date of Membership
Hammatt, William Cushing. Chf. Engr., Miller & Lux, Inc., and San Joaquin & Kings River Canal & Irrig. Co., Inc., 1313 Merchants Exchange, San Francisco, Cal. (*Assoc. M., Sept. 5, 1900*)	Oct. 5, 1909
Hammond, Alonzo John. Chf. Engr., Bureau of Public Efficiency of Chicago; Cons. Engr., Suite 207, Summers Bldg., South Bend, Ind.	June 1, 1904
Hammond, Charles Adrian. Mgr., Mt. Vernon Sewage Disposal Works, Columbus Ave., Foot of 7th St. (Res., 301 South 4th Ave.), Mt. Vernon, N. Y.	April 6, 1909
Hammond, Charles Lincoln. Engr., Conners Bros. Co. (Res., 69 Forrest St.), Lowell, Mass.	May 3, 1910
Hammond, George Tillinghast. 156 Berkeley Pl., Brooklyn, N. Y.	Feb. 7, 1906
Hammond, John Farnsworth. Cons. Engr., 123 Oak St., Richmond Hill, N. Y.	Feb. 7, 1906
Hancock, Robert Rives. Secy. of The Philippine Ry., 43 Exchange Pl., New York City	Dec. 1, 1908
Hand, Franklin Clark. Chf. Engr., Oklahoma Central Ry., Purcell, Okla.	Feb. 6, 1907
Handbury, Thomas Henry. Col., Corps of Engrs., U. S. A. (*Retired*), Care, Hong Kong-Shanghai Banking Corporation, Tientsin, China	Feb. 3, 1904
Hanna, John Hunter. Chf. Engr., The Capital Traction Co., 36th and M Sts., Washington, D. C. (*Assoc. M., April 3, 1901*)	Nov. 1, 1904
Hanna, John Venable. Chf. Engr., Kansas City Terminal Ry., 23d and Grand Ave., Kansas City, Mo. (*Assoc. M., May 3, 1893*)	April 2, 1902
Hansel, Charles. Pres., Charles Hansel & Co., 43 Wall St., New York City	Oct. 3, 1894
Hansen, Andrew Christian. Insp. of Public Works, Los Angeles, Cal.	Oct. 4, 1910
Harahan, William Johnson. Asst. to Pres., Erie R. R., 50 Church St., New York City. (*Assoc. M., Oct. 3, 1894*)	Oct. 7, 1903
C. Harby, Isaac. Chf. Engr., Sage Foundation Homes Co., Forest Hills, N. Y. (*Jun., June 6, 1899; Assoc. M., May 6, 1903*)	May 2, 1911
Hardaway, Benjamin Hurt. Contr. Engr., Columbus, Ga.	Oct. 7, 1903
Hardee, William Joseph. City Engr., Room 19, City Hall, New Orleans, La.	May 6, 1896
Harding, Chester. Maj., Corps of Engrs., U. S. A., Gatun, Canal Zone, Panama	Oct. 4, 1905
Hardy, Edward Dana. Supt. of Washington Aqueduct and Filtration Plant, Washington, D. C.	Oct. 5, 1904
Hardy, George Fiske. 309 Broadway, New York City	Mar. 1, 1905
Hardy, Harry. San José, Costa Rica. (*Assoc. M., June 1, 1892*)	June 1, 1909
Haring, Alexander. Prof. of Bridge and Railway Eng., New York Univ.; Attorney and Counselor at Law, 74 West Tremont Ave., Bronx, New York City	April 4, 1906
Haring, James Smith. 35 Bradford Ave., Crafton, Pa.	Nov. 4, 1891
Harkness, George Edward. Constr. Engr., Holbrook, Cabot & Rollins, 6 Beacon St., Boston, Mass.	June 1, 1909
Harley, Alfred Francis. Cons. Engr., 136 East Bay St., Jacksonville, Fla.	Dec. 7, 1898
Harlow, George Richardson. 3 East Lexington St., Room 53, Baltimore, Md.	Nov. 1, 1899
Harlow, James Hayward. Chf. Engr., Susquehanna Power Co., Darlington, Md.	Mar. 4, 1874
Harman, Eugene Leonard. U. S. Asst. Engr. with Miss. River Comm., 1307 Liggett Bldg., St. Louis, Mo.	Oct. 3, 1906
Harman, Jacob Anthony. (Harman Eng. Co.), 120 Fredonia Ave., Peoria, Ill. (*Assoc. M., May 4, 1898*)	Jan. 2, 1912
Harper, Edgar Ambler. Care, Bituminized Road Co., 417 Reliance Bldg., Kansas City, Mo.	June 7, 1905
Harper, John Lyell. Chf. Engr., Hydr. Power Co. and Cliff Elec. Distributing Co., Niagara Falls, N. Y.	June 5, 1907
Harrington, Ephraim. Cons. and Advisory Engr., 20 Pemberton Sq., Boston, Mass.	Mar. 3, 1897
Harrington, Ferdinand Finney. Engr. of Structures, Virginian Ry., Norfolk, Va. (*Assoc. M., May 3, 1899*)	Feb. 2, 1909
Harrington, John Lyle. Cons. Engr. (Waddell & Harrington), 1012 Baltimore Ave., Kansas City, Mo. (*Jun., Aug. 31, 1897; Assoc. M., Oct. 4, 1899*)	Dec. 1, 1903
Harris, Elmo Golightly. Prof. of Civ. Eng., Mo. School of Mines, Rolla, Mo.	Oct. 2, 1901
Harris, Frederic Robert. Civ. Engr., U. S. N.; Head of Dept. of Public Works, U. S. Navy Yard, Brooklyn, N. Y.	June 30, 1910
Harris, George Brodhead. Pres., York Haven Water & Power Co.; Vice-Pres., Hazard, Hillman & Harris, Oak Rd., Germantown, Philadelphia, Pa.	May 2, 1911
Harris, Stephen. 7219 Boyer St., Mt. Airy, Philadelphia, Pa.	June 4, 1902
Harris, Van Alen. Mgr., Central Romana, La Romana, Santo Domingo, (*Jun., Nov. 6, 1894; Assoc. M., Oct. 5, 1898*)	Sept. 6, 1904
Harrison, Burr Powell. U. S. Junior Engr., Baltimore, Md.	Oct. 3, 1911

		Date of Membership
R.	Harrison, Charles Lewis. 7 East 42d St., New York City	Mar. 2, 1898
	Harrison, Edlow Wingate. Cons. Engr.; Chf. Engr., Passaic Val. Sewerage Commrs., 15 Exchange Pl., Jersey City, N. J	June 3, 1885
	Harrison, Edmund Pendleton Hunter. Vice-Pres., Eyre-Shoemaker, Inc., 900 Arcade Bldg., Philadelphia, Pa	May 1, 1907
	HARROD, BENJAMIN MORGAN. (*Past-President*). Cons. Engr., 1637 Foucher St., New Orleans, La	April 4, 1877
	Harroun, Philip Embury. Hydr. Engr., Berkeley, Cal	Mar. 7, 1900
	Harte, Charles Rufus. Asst. Engr., N. Y., N. H. & H. R. R., Room 308, R. R. Bldg., New Haven, Conn. (*Jun., April 4, 1899; Assoc. M., May 2, 1900*)	Nov. 5, 1907
	Hartigan, Frederick Lawrence. 701 West 179th St., New York City. (*Assoc. M., May 6, 1903*)	Mar. 31, 1908
	Hartman, Russell Theodore. Care, Des Moines Bridge & Iron Works, Des Moines, Iowa. (*Assoc. M., May 4, 1909*)	Nov. 1, 1910
	Hartrick, Edward Macaulay. U. S. Asst. Engr., River and Harbor Impvts., Galveston, Tex	Feb. 1, 1899
R.	Harts, William Wright. Maj., Corps of Engrs., U. S. A., War Coll., Washington, D. C. (*Assoc. M., Oct. 2, 1895*)	April 6, 1898
	Hartwell, Harry. 1414 Douglas St., Victoria, B. C., Canada. (*Jun., Jan. 2, 1894; Assoc. M., Feb. 2, 1898*)	Jan. 3, 1907
	Hartwell, Herbert Clifford. Asst. Engr., Boston Elev. Ry., 101 Milk St., Boston, Mass	Oct. 7, 1908
	Harwood, George Alec. Chf. Engr., Electric Zone Impvts., N. Y. C. & H. R. R. R., 335 Madison Ave., Room 1206, New York City. (*Assoc. M., Feb. 5, 1902*)	Feb. 5, 1907
	Harwood, Thomas Triplett Hunter. Asst. Engr., U. S. Engr. Office, 25 Pemberton Sq., Boston, Mass	April 5. 1910
	Haskell, Eugene Elwin. Director, Coll. of Civ. Eng., Cornell Univ., Ithaca, N. Y	Sept. 7, 1898
	Haskins, William Jewett. Cons. Engr. and Contr., 50 Church St., Room 469, New York City. (*Jun., Mar. 7, 1883*)	Dec. 1, 1886
	Haslam, Erwin Ernest. Engr., International Waterways Comm., Am. Section, 328 Federal Bldg., Buffalo, N. Y	July 1, 1909
	Hasskarl, Joseph Frederick. Director, Dept. of Wharves, Docks and Ferries (Res., 1603 Girard Ave.), Philadelphia, Pa. (*Assoc. M., Mar. 5, 1902*)	Nov. 1, 1904
	Hastings, Frank Arnold. Structural and Cons. Engr., Schmulbach Bldg., Wheeling, W. Va. (Res., Martins Ferry, Ohio). (*Assoc. M., Dec. 3, 1902*)	May 31, 1910
	Hatch, Frederick Thomas. Chf. Engr., Vandalia R. R., 850 Century Bldg., St. Louis, Mo	Dec. 4, 1889
	Hatch, James Noble. Structural Engr. for Sargent & Lundy, 1720 Railway Exchange, Chicago, Ill	Dec. 7, 1904
	Hatton, Thomas Chalkley. Cons. Engr., Wilmington, Del	Mar. 6, 1895
	Haugh, James Charles. Res. Engr., New Orleans & North Eastern R. R., Press and Levee Sts., New Orleans, La	Feb. 2, 1909
	Haupt, Lewis Muhlenberg. Cons. Engr., 107 North 35th St., Philadelphia, Pa	June 6, 1888
	Haven, William Appleton. 812 Potomac Ave., Buffalo, N. Y	Mar. 5, 1873
	Haviland, Arthur. Engr., Land and Tax Dept., N. Y. C. & H. R. R. R., 335 Madison Ave., Room 1102, New York City. (*Jun., Jan. 4, 1882*).	Jan. 4, 1888
	Hawgood, Harry. Cons. Engr., 722 H. W. Hellman Bldg., Los Angeles, Cal	May 4, 1909
	Hawks, James Dudley. Pres., D. & M. Ry., Majestic Bldg., Detroit, Mich.	Dec. 3, 1884
	Hawksley, Kenneth Phipson. Caxton House, Westminster, S. W., London, England	May 6, 1903
	Hawley, John Blackstock. Cons. Engr., Fort Worth, Tex. (*Assoc. M., May 1, 1895*)	Oct. 5, 1898
	Hawley, Ralph Stevenson. Berkeley, Cal	Dec. 5, 1911
	Hawley, William Chauncey. Chf. Engr. and Gen. Supt., Pennsylvania Water Co., 701 Wood St., Wilkinsburg, Pa. (*Jun., Oct. 1, 1890; Assoc. M., April 6, 1892*)	Dec. 3, 1902
	Hawxhurst, Robert, Jr. Cons. Engr., Care, International Banking Corporation. 36 Bishopgate, London, E. C., England, (*Assoc. M., Sept. 7, 1904*)	Dec. 3, 1907
	Hayden, John Bruce. 376 Genesee St., Utica, N. Y. (*Assoc. M., May 2, 1900*)	May 5, 1908
	Hayden, William Wallace. Chf. Engr., Lake View Traction Co., N. Memphis Savings Bank, Memphis, Tenn	Nov. 6, 1895
	Hayes, Edmund. 816 Fidelity Bldg., Buffalo, N. Y. (*Jun., April 3, 1878*).	Mar. 5, 1884
	Hayes, Edward. Advisory Engr., State Supt. of Public Works, Albany, N. Y	June 5, 1901
	Hayes, George Samuel. Cons. Engr., 1123 Broadway, New York City. (*Jun., Dec. 6, 1892; Assoc. M., June 3, 1896*)	Sept. 2, 1903

	Date of Membership
Hayes, Henry Wilde. Mass. Engr. of Grade Crossings, 8 Beacon St., Boston, Mass. *(Assoc. M., Mar. 2, 1898)*	May 1, 1901
Hayes, Stanley Wolcott. Pres., Hayes Track Appliance Co., Richmond, Ind.	June 6, 1900
Hayford, John Fillmore. Director, Coll. of Eng., Northwestern Univ., Evanston, Ill. *(Assoc. M., May 6, 1896)*	April 2, 1907
Haylow, James Henry. Chf. Engr., Memphis St. Ry., P. O. Box 341, Memphis, Tenn. *(Assoc. M., Dec. 5, 1906)*	Oct. 3, 1911
Hays, John Willis. 3 South Adams St., Petersburg, Va.	June 5, 1901
Hayt, Robert Olcott. Engr., U. S. Reclamation Service, Helena, Mont. *(Assoc. M., Oct. 3, 1906)*	June 30, 1910
Hayt, Stephen Thurston, Jr. Chf. Engr., Susq. & N. Y. R. R., 849 Louisa St., Williamsport, Pa.	Mar. 3, 1897
Hayward, Robert Francis. Gen. Mgr., Western Canada Power Co., Ltd., Vancouver, B. C., Canada	July 10, 1907
Hazard, Schuyler. Gen. Mgr. and Chf. Engr., Orleans County Quarry Co., Albion, N. Y.	Oct. 5, 1898
Hazelton, Charles William. Engr. and Treas., Turners Falls Co. (Water Power), Turners Falls, Mass.	Jan. 7, 1891
R. Hazen, Allen. Cons. Engr. (Hazen & Whipple), 103 Park Ave., New York City. *(Assoc. M., June 3, 1896)*	Mar. 6, 1900
Hazen, John Vose. Prof. of Civ. Eng. and Graphics, Dartmouth Coll., 33 North Main St., Hanover, N. H. *(Assoc., June 5, 1889)*	May 2, 1911
Hazen, William Nelson. Engr. for Am. Concrete Steel Co., Union Bldg., Newark, N. J. *(Assoc. M., Dec. 3, 1902)*	Nov. 8, 1909
Hazlehurst, George Blagden. Cons. Engr., Catonsville, Md.	Feb. 1, 1888
Hazlehurst, James Nisbet. Cons. Engr., 532 Candler Bldg., Atlanta, Ga.	Oct. 4, 1899
Heald, Simpson Clark. Greenville, N. H.	Nov. 4, 1885
Healy, John Francis. Gen. Mgr., Operating Dept., Davis Colliery Co., Western Maryland Bldg., Elkins, W. Va. *(Jun., Jan. 2, 1890; Assoc. M., June 3, 1891)*	Nov. 1, 1899
Heckle, George Rogers. Care, Ambursen Hydr. Constr. Co. of Canada, Ltd., 405 Dorchester St., W., Montreal, Que., Canada. *(Assoc. M., Feb. 7, 1906)*	Jan. 3, 1911
Hedges, Samuel Hamilton. Pres., Puget Sound Bridge & Dredging Co., 432 Central Bldg., Seattle, Wash.	July 10, 1907
Hedke, Charles Richard. Box 1106, Fort Collins, Colo.	June 6, 1911
Hedrick, Ira Grant. Cons. Engr. (Hedrick & Cochrane), 1118 McGee St., Kansas City, Mo. *(Jun., Oct. 3, 1893; Assoc. M., June 2, 1897)*	Nov. 7, 1900
Hegardt, Gustave Bernard. (Hegardt & Clarke), 1010 Board of Trade Bldg., Portland, Ore.	Oct. 7, 1908
Heldt, Hans Ludwig. Supt., The Sombrerete Min. Co., Sombrerete, Zac., Mexico	June 5, 1907
Hem, Halvor Olsen. Supt. and Vice-Pres., The H. M. Strait Mfg. Co., 721 West 18th St., Kansas City, Mo.	Sept. 5, 1911
Hench, Norman MacPherson. Engr., Track Appliances, Carnegie Steel Co., Carnegie Bldg., Pittsburgh, Pa.	May 2, 1906
Henderer, William Oswald. Pres., The Osborn Eng. Co., Osborn Bldg., Cleveland, Ohio	April 3, 1901
Henderson, John Baillie. Govt. Hydr. Engr., Water Supply Dept., Brisbane, Queensland, Australia	June 4, 1890
Henderson, John Thomas. Chf. Engr., Conn. River Bridge and Highway Dist., 756 Main St., Hartford, Conn. *(Assoc. M., Sept. 3, 1902)*	Sept. 3, 1907
Hendrick, Calvin Wheeler. Chf. Engr., Baltimore Sewerage Comm., American Bldg., Baltimore, Md.	Nov. 7, 1900
Hendricks, Victor King. Prin. Asst. Engr., St. L. & S. F. R. R. and C. & E. I. R. R., Springfield, Mo. *(Assoc. M., May 1, 1895)*	April 4, 1911
Hengst, Robert Graham. Duquesne Contr. Co., Pittsburgh (Res., 325 Wallace Ave., New Castle), Pa. *(Assoc. M., Oct. 7, 1903)*	May 5, 1908
Henny, David Christiaan. Cons. Hydr. Engr., 605 Spalding Bldg., Portland, Ore.	Sept. 7, 1887
Henoch, Milton Jacob. Archt. and Engr. (Jenkinson & Henoch), 406 United Bank Bldg., Sioux City, Iowa	Dec. 5, 1911
Henry, George Jackson, Jr. Hydr. and Mech. Engr., Room 737, Rialto Bldg., San Francisco, Cal.	April 5, 1910
Henry, Philip Walter. Cons. Engr., 25 Broad St., New York City. *(Assoc. M., Jan. 3, 1894)*	Nov. 2, 1908
Hepburn, Frederick Taylor. Banker (H. D. Walbridge & Co.), 7 Wall St., New York City	June 6, 1906
Herbert, Arthur Powis. Apartado 67, Colima, Colima, Mexico	Sept. 5, 1888
Herbert, Harry Monmouth. Chf. Engr., City Water Dept., City Hall, Camden, N. J.	April 6, 1898
Hering, Rudolph. Hydr. and San. Engr., 170 Broadway, New York City.	Jan. 5, 1876
Hermann, Edward Adolph. Pres., Reliance Quarry & Constr. Co., 1026 Langdon St., Alton, Ill.	April 6, 1887

		Date of Membership
	Herrick, Charles Hubbard. New England Representative, National Meter Co., Gas Engine Dept., 159 Franklin St., Boston (Res., High St., Winchester), Mass	Sept. 5, 1911
	Herrick, Henry Augustus. Hydr. and Mill Engr., 331 Forsyth Bldg., Fresno, Cal. (Res., 242 Prospect St., Manchester, N. H.)	May 7, 1890
	Herring, Willard E. Dist. Engr., U. S. Forest Service, Portland, Ore. (*Assoc. M., Sept. 4, 1901*)	Jan. 3, 1907
	Herrmann, Frederick Charles. Constr. Engr., Spring Val. Water Co., 375 Sutter St., San Francisco, Cal	Nov. 6, 1907
	Herron, John. Box 463. Palo Alto, Cal	Oct. 4, 1893
R.	Herschel, Clemens. Hydr. Engr., 2 Wall St., New York City	April 21, 1869
	Hesse, Fred. 471 East Alder St., Portland, Ore	June 3, 1908
	Heuer, William Henry. Col., U. S. A. (*Retired*), 851 Pacific Bldg., San Francisco, Cal	Mar. 3, 1880
	Hewes, Virgil Henry. Mgr. and Treas., The Zwoyer Fuel Co., 60 Wall St., Room 2602 (Res., 161 West 103d St.), New York City	Feb. 3, 1904
R.	Hewett, Bertram Henry Majendie. Care, Jacobs & Davies, 30 Church St., New York City. (*Assoc. M., April 5, 1905*)	Oct. 1, 1907
	Hewett, William Sherman. Box 1004, Minneapolis, Minn	June 1, 1909
	Hewins, George Sanford. Constr. Supt., J. G. White & Co., Inc., 821 Electric Bldg., Portland, Ore	Oct. 7, 1908
	Hewitt, Charles Edward. Trenton, N. J	Oct. 5, 1887
	Hickok, Henry Addison. Cons. and Const. Engr., Union Bldg., Newark, N. J	Oct. 7, 1896
	Hider, Arthur. U. S. Asst. Engr.; Res. Engr. in Local Chg. of Impvts., Lake Providence Reach, Mississippi River, Greenville, Miss	Sept. 7, 1881
	Higgins, Charles Houchin. Cons. Engr., 15 Exchange Pl., Jersey City, N. J. (*Jun., Jan. 2, 1906; Assoc. M., April 1, 1908*)	Dec. 5, 1911
	Higgins, George. Lecturer in Civ. Eng., Melbourne Univ., Melbourne, Victoria, Australia	Oct. 2, 1907
	Higgins, Horace Longuet. Pres. and Engr.-in-Chf., The Manila R. R., Manila, Philippine Islands	May 2, 1906
	Hilgard, Karl Emil. Prof.; Cons. Civ. Engr., 18 Steinwiesstrasse, Zurich, V., Switzerland	June 4, 1890
	Hill, Albert Banks. Cons. Engr., 100 Crown St., New Haven, Conn. (*Jun., Feb. 2, 1876*)	Mar. 5, 1884
	Hill, Cicero Demerit. 1722 W. 101st St., Chicago, Ill	April 4, 1906
	Hill, Curtis. State Highway Engr., Columbia Mo. (*Assoc. M., Oct. 2, 1901*)	Jan. 3, 1907
	Hill, Ernest Rowland. Cons. Engr. (Gibbs & Hill), Pennsylvania Station, New York City	July 10, 1907
	Hill, George. Builder, 31 East 27th St., New York City. (*Assoc. M., Oct. 4, 1893*)	Feb. 1, 1899
	Hill, Henry Francis. 12 Allen Bldg., Augusta, Me	Mar. 6, 1907
	Hill, John Edward. Prof. of Civ. Eng., Brown Univ., Providence, R. I. (*Assoc. M., May 4, 1892*)	Mar. 31, 1908
	Hill, John Willmuth. 506 First National Bank Bldg., Cincinnati, Ohio. (*Jun., Feb. 3, 1875*)	April 5, 1876
	Hill, Louis Clarence. Phœnix, Ariz	Oct. 4, 1905
	Hill, Walter Hovey. Cons. Engr., Grangeville, Idaho	June 5, 1901
R.	Hill, William Ryan. Cons. Engr., 53 State St., Albany, N. Y	July 1, 1891
	Hilliard, Foster Haven. U. S. Asst. Engr.; Supt. of Dredging Operations with the Mississippi River Comm., Box 1017, Memphis, Tenn. (*Assoc. M., Mar. 6, 1901*)	May 1, 1906
	Hillyer, William Ross. Asst. Commr. of Public Works, Borough of Richmond, City of New York, Borough Hall, St. George (Res., Palmer Ave., Port Richmond), N. Y	May 6, 1903
	Himes, Albert James. Engr. of Grade Elimination, N. Y. C. & St. L. R. R., Hickox Bldg., Cleveland, Ohio. (*Assoc. M., Nov. 6, 1895*)	June 7, 1899
	Himmelwright, Abraham Lincoln Artman. Cons. Engr., Masonic Hall Annex, 23d St. and 6th Ave., New York City	Oct. 5, 1898
	Hinckley, Howard Vernon. Cons. Engr., 1018 North Harvey, Oklahoma, Okla.	Dec. 5, 1883
	Hinderlider, Michael Creed. Cons. and Superv. Engr., 435 Century Bldg., Denver, Colo	Jan. 3, 1911
	Hindes, Stetson George. Pres., Atlantic, Gulf & Pacific Co. and San Francisco Bridge Co., 865 Monadnock Bldg., San Francisco, Cal	June 3, 1903
	Hinds, Franklin Allen. Cons. Engr., 28 Flower Bldg., Watertown, N. Y.	May 3, 1899
	Hiroi, Isami. Care, Coll. of Eng., Tokyo Imperial Univ., Tokyo, Japan	Dec. 1, 1908
	Hitchcock, Frederick Collamore. Vice-Pres. and Gen. Mgr., MacArthur Bros. Co., 11 Pine St., New York City. (*Assoc. M., Mar. 7, 1894*)	Feb. 6, 1895
	Hittell, John Benjamin. Chf. Engr. of Streets, Board of Local Impvts., 206 City Hall (Res., 5917 Winthrop Ave.), Chicago, Ill	July 1, 1909
	Hoag, Sidney Willett, Jr. Deputy Chf. Engr., Dept. of Docks and Ferries, Pier A, North River, New York City	Sept. 2, 1885

	Date of Membership
Hobbs, Henry Webster. U. S. Asst. Engr., 537 Congress St., Portland, Me.	June 30, 1911
Hobby, Arthur Stanley. Cons. Engr., Box 37, Guayaquil, Ecuador. (*Assoc. M., Sept. 4, 1901*)	June 4, 1907
Hobson, Joseph. 346 Bay St. (South), Hamilton, Ont., Canada	Feb. 5, 1890
Hocke, Julius George. Secy. and Treas., General Contr. & Eng. Co., 29 Broadway, New York City (Res., 669 Ave. C, Bayonne, N. J.)	April 3, 1907
Hodgdon, Frank Wellington. Chf. Engr., Mass. Board, Harbor and Land Commrs., Room 131, State House, Boston, Mass.	Dec. 3, 1884
Hodge, Harry Seymour. 83 Alfred St., Detroit, Mich.	Oct. 3, 1894
Hodge, Henry Wilson. Cons. Engr. (Boller, Hodge & Baird), 149 Broadway, New York City. (*Jun., Jan. 5, 1887*)	Oct. 2, 1895
Hodges, Gilbert. Cons. Engr., Hill, N. H.	June 4, 1890
Hodges, Harry Foote. Col., Corps of Engrs., U. S. A.; Member and Asst. Chf. Engr., Isthmian Canal Comm., Culebra, Canal Zone, Panama	Mar. 4, 1903
Hodgkins, Henry Clarence. Cons. Engr., 514 Dillaye Bldg., Syracuse, N. Y.	June 6, 1911
Hodgman, Harry. U. S. Asst. Engr., Detroit River Impvt., Amherstburg, Ont., Canada. (*Assoc. M., Mar. 2, 1904*)	May 31, 1910
Hoff, Olaf. Cons. Engr., 149 Broadway, New York City	May 6, 1885
Hoffman, Nathaniel Baker Klink. Asst. Engr., Bureau of Sewers, Borough of the Bronx, 2683 Creston Ave., New York City	Nov. 6, 1901
Hoffmann, Robert. Chf. Engr., Dept. of Public Service (Res., 1871 East 87th St.), Cleveland, Ohio. (*Assoc. M., June 5, 1901*)	Sept. 6, 1904
Hogeland, Albert Harrison. Chf. Engr., G. N. Ry., St. Paul, Minn.	May 2, 1906
Hogg, James Breading. Civ. and Min. Engr., Connellsville, Pa.	Oct. 3, 1906
Hogue, Chester James. Const. Engr., The Concrete Eng. Co., 1104 Oliver Bldg., Boston, Mass. (*Assoc. M., Dec. 6, 1905*)	June 6, 1911
Hohl, Leonhard John. Cons. Engr., 618 Marvin Bldg., San Francisco, Cal.	Oct. 5, 1904
Holbrook, Elliot. Special Engr., U. P. System, S. P. Co., Room 1011, Union Pacific Bldg., Omaha, Nebr.	Sept. 3, 1902
Holbrook, Frank Dudley. U. S. Asst. Engr., New Martinsville, W. Va. (*Assoc. M., Feb. 1, 1905*)	Jan. 7, 1908
Holbrook, Frederick William Doane. Navy Yard, Puget Sound, Bremerton, Kitsap Co., Wash.	Oct. 6, 1886
Holbrook, John Byers. Cons. Engr., 3 South William St., New York City.	April 6, 1909
Holcombe, Joseph Gales. Chf. Engr. and Director of Public Works, Panama, Panama	May 4, 1904
Holden, Edward Henry. Asst. Engr., Topographical Bureau, Borough of the Bronx, 177th St. and 3d Ave. (Res., 1074 Boston Rd., Bronx), New York City	May 6, 1908
Holgate, Henry. Cons. Engr., 9 Victoria Sq., Montreal, Que., Canada	Oct. 2, 1901
Hollyday, Richard Carmichael. Civ. Engr., U. S. N.; Chf. of Bureau of Yards and Docks, Navy Dept., Washington, D. C.	Sept. 2, 1903
Holman, Minard Lafever. Cons. Engr. (Holman & Laird), 3744 Finney Ave., St. Louis, Mo.	April 2, 1884
Holmes, Glenn Dickinson. Chf. Engr., Intercepting Sewer Board, Room 104, City Hall, Syracuse, N. Y. (*Assoc. M., June 5, 1901*)	Mar. 5, 1907
Holmes, Howard Carleton. Cons. Engr.; Chf. Engr., San Francisco Dry Dock Co.; Chf. Engr., S. F., O. & S. J. Ry.; Cons. Engr., Docks and Wharfs, West. Pac. Ry., 112 Market St., San Francisco, Cal.	Nov. 4, 1903
Holmes, Lemuel. Engr. of Bridges, New York State Highway Comm., 12 South Hawk St., Albany, N. Y.	Mar. 1, 1910
Holt, Arthur Grant. Div. Engr., C., M. & P. S. Ry., 258 Front Ave., Spokane, Wash.	April 5, 1910
Holt, Herbert Samuel. 297 Stanley St., Montreal, Que., Canada	Mar. 6, 1889
Holtzman, Stephen Ford. 11 East 24th St., New York City (Res., Hastings-on-Hudson, N. Y.). (*Assoc. M., Mar. 7, 1906*)	Nov. 1, 1910
Homberger, Heinrich. Cons. Engr., Room 864, Pacific Bldg., San Francisco, Cal.	Oct. 5, 1909
Hone, Frederic de Peyster. (Frederic de P. Hone & Co.), 1 Liberty St., New York City. (*Jun., April 4, 1899; Assoc. M., Feb. 5, 1902*)	May 5, 1908
Honens, Frederick William. U. S. Asst. Engr., U. S. Engr. Office, Postal Telegraph Bldg. (Res., 3917 Belleview Ave.), Kansas City, Mo. (*Assoc. M., April 3, 1901*)	May 31, 1904
Hood, John Mifflin, Jr. Secy., Crown Cork & Seal Co.; Chf. Engr., United Rys. & Elec. Co., 1008 Continental Bldg., Baltimore, Md. (*Jun., May 31, 1904; Assoc. M., June 6, 1906*)	Sept. 6, 1910
Hood, Richard Haden. 541 Stelle Ave., Plainfield, N. J. (*Assoc. M., May 3, 1893*)	Nov. 2, 1898
Hood, William. Chf. Engr., S. P. Co., Room 1136, James Flood Bldg., San Francisco, Cal.	Oct. 7, 1896
Hook, Gulian Schmalz. 705 Union St., Schenectady, N. Y.	April 3, 1901
Hoover, Herbert Clark. Red House, Hornton St., London, England	Jan. 4, 1910

	Date of Membership
Hoover, Joseph Warren. 537 New York Life Bldg., Kansas City, Mo	June 6, 1888
Hopkins, Charles Comstock. Hydr. and San. Engr. (Knight & Hopkins), 349 Cutler Bldg., Rochester, N. Y	June 4, 1890
Hopkins, Newton Fisher. With Harrop, Hopkins & Taylor, 900 Lewis Bldg., Pittsburgh, Pa. (*Assoc. M., Oct. 2, 1907*)	Oct. 4, 1910
Hopkins, Stephen Upshur. Constr. Engr., Bradley Contr. Co., 4th Ave. and 3d St., Brooklyn, N. Y	Oct. 5, 1909
Hopson, Ernest George. Superv. Engr., U. S. Reclamation Service, 132 Tenth St., Portland, Ore	July 10, 1907
Horn, Frank Churchill. Cons. Engr., Suite 516, Empire Bldg., Boise, Idaho	Sept. 1, 1903
Hornsby, Robert Wright. Care, George Hornsby, 80 Church St., Edgeware Rd., London, England	Nov. 4, 1908
Horrocks, John Irvin. Asst. Engr., C., M. & Puget Sound Ry., Room 617, White Bldg., Seattle, Wash	Dec. 5, 1911
Horton, George Terry. Engr. and Mgr., Chicago Bridge & Iron Works, 105th and Throop Sts., Chicago, Ill	April 6, 1904
Horton, Horace E. Prop., Chicago Bridge & Iron Works, Chicago, Ill	Sept. 6, 1882
Horton, Robert Elmer. Cons. Hydr. Engr., 57 North Pine Ave., Albany, N. Y. (*Assoc. M., Dec. 7, 1904*)	May 31, 1910
Horton, Theodore. Chf. Engr., New York State Dept. of Health, Albany, N. Y. (*Jun., Aug. 31, 1897; Assoc. M., April 4, 1900*)	June 6, 1905
Hotchkiss, Charles Wilcox. Gen. Mgr., Chi., Ind. & South. R. R., Indiana Harbor Belt R. R., 511 La Salle St. Station, Chicago, Ill	Jan. 5, 1898
Hotchkiss, Louis Jenison. Asst. Bridge Engr., C., B. & Q. R. R., 226 West Adams St., Chicago, Ill	Nov. 30, 1909
Hough, David Leavitt. Pres., The United Eng. & Contr. Co. and The Cuban Eng. & Contr. Co., 17 West 42d St., New York City	May 5, 1897
Hough, Ulysses B. Civ. and Mech. Engr., 616 Realty Bldg., Spokane, Wash	Nov. 5, 1902
House, Francis Edwin. Pres., D. & I. R. R. R., Duluth, Minn	May 1, 1895
Houston, Gavin Nelson. Cons. and Superv. Engr., 409 Equitable Bldg., Denver, Colo. (*Jun., May 4, 1897; Assoc. M., Nov. 7, 1900*)	Feb. 2, 1909
Hovey, Otis Ellis. Asst. Chf. Engr., Am. Bridge Co. of N. Y., 30 Church St., New York City. (*Assoc. M., April 4, 1894*)	Jan. 3, 1900
How, Richard Willis. R. D. 3, Perry, N. Y. (*Jun., June 6, 1899; Assoc. M., Mar. 1, 1905*)	June 30, 1910
Howard, Charles Pope. Asst. Engr., I. C. R. R., Chicago, Ill. (*Assoc. M., Jan. 3, 1894*)	Oct. 31, 1905
Howard, Edward Henry. Chf. Engr., Boston & Worcester St. Ry., South Framingham, Mass	May 31, 1910
Howard, Frederick Billings. 30 Alexandrine Ave., E., Detroit, Mich. (*Jun., Mar. 3, 1875*)	Nov. 6, 1878
Howard, John Lewis. Res. Engr., Farnham Dam, New Lenox, Mass. (*Assoc. M., Dec. 7, 1898*)	April 2, 1902
Howe, Edward Willard. Engr., Special Work, Bridge and Ferry Div., Public Works Dept., 62 City Hall, Boston, Mass	Sept. 7, 1887
Howe, George Edward. Wauseon, Ohio. (*Assoc. M., Mar. 4, 1903*)	April 30, 1907
Howe, Joseph Milton. Cons. Engr. (Howe & Wise), 722 First National Bank Bldg., Houston, Tex. (*Assoc. M., Feb. 4, 1903*)	Jan. 7, 1908
Howe, Malverd Abijah. Prof., Civ. Eng., Rose Polytechnic Inst., 2108 North 10th St., Terre Haute, Ind. (*Assoc., May 7, 1890*)	Jan. 1, 1896
Howe, William Bell White. Hendersonville, N. C	Mar. 1, 1893
Howell, David Janney. Union Trust Bldg., 15th and H Sts., N. W., Washington, D. C	Sept. 5, 1900
Howell, Franklin Davinport. Pres., The Pacific Co., Suite 548, I. W. Hellman Bldg., Los Angeles, Cal	June 5, 1901
Howell, George Pierce. Maj., Corps of Engrs., U. S. A., U. S. Engr. Office, Charleston, S. C	Feb. 2, 1909
Howell, William Augustus. Engr., Streets and Highways, City Hall, Newark, N. J. (*Assoc. M., April 3, 1907*)	June 6, 1911
Howells, Julius Merriam. 2806 Derby St., Berkeley, Cal	June 4, 1902
Howes, Robert. Cons. Engr., 1102 Am. Bank Bldg., Seattle, Wash	Jan. 2, 1912
Hoxie, Richard Leveridge. Brig.-Gen., U. S. A. (*Retired*), 1632 K St., N. W., Washington, D. C	June 2, 1886
Hoyt, John Clayton. Engr. in Chg., Surface Water Investigations, U. S. Geological Survey, 1330 F St., N. W., Washington, D. C. (*Assoc. M., May 4, 1904*)	June 1, 1909
Hoyt, Warren Albert. Cons. and Contr. Engr., 455 Old Colony Bldg., Chicago, Ill	June 30, 1910
Hoyt, William Edwin. Cons. Engr. and Special Engr., N. Y. C. & H. R. R. R. (Res., 50 Westminster Rd.), Rochester, N. Y	Mar. 5, 1884
Hoyt, William Hausmer. Asst. Chf. Engr., Duluth, Missabe & Northern Ry., 401 Wolvin Bldg., Duluth, Minn	June 30, 1911
Hubbard, Isaac Wendell. (Pugh & Hubbard), 601 Witherspoon Bldg., Philadelphia, Pa. (*Assoc. M., Mar. 1, 1905*)	Jan. 4, 1910

	Date of Membership
N. Hubbell, Clarence William. Chf. Engr., Bureau, Public Works, Philippine Islands, Manila, Philippine Islands. (*Jun., May 31, 1898; Assoc. M., April 4, 1900*)	Jan. 5, 1904
Hudson, Clarence Walter. Prof. of Civ. Eng., Polytechnic Inst. of Brooklyn; Cons. Engr., 45 Broadway, New York City. (*Assoc. M., Nov. 7, 1894*)	Feb. 7, 1900
Hudson, John Rogers. 5353 Minerva Ave., St. Louis, Mo	May 4, 1887
Huggins, William. Praca 13 de Maio No. 1, São Vicente, Santos, Brazil	Feb. 7, 1906
Hughes, David Edward. U. S. Engr. Office, 723 Central Bldg., Los Angeles, Cal	Sept. 6, 1905
Hughes, Hector James. Asst. Prof. of Civ Eng., Harvard Univ., and Cons. Engr., 114 Pierce Hall, Cambridge, Mass	May 3, 1905
Hughes, John Wilbur. Civ. Engr., Pennsylvania Gen. Elec. Co., 939 West 10th St., Erie, Pa	June 30, 1910
Hughes, William Mackenzie. Cons. Bridge Engr., 532 Postal Telegraph Bldg., Chicago, Ill	June 2, 1880
Hull, George Beckley. Asst. Engr., Dept., Public Works, Dominion of Canada, North Temiskaming, Que., Canada	May 2, 1911
Humphrey, Richard Lewis. Cons. Engr., 805 Harrison Bldg., Philadelphia, Pa. (*Assoc. M., May 5, 1897*)	May 3, 1904
Humphreys, Alexander Crombie. Pres., Humphreys & Glasgow, Inc., Buffalo Gas Co., and Stevens Inst. of Tech., 165 Broadway, New York City	Mar. 6, 1895
Humphreys, Clifton Stewart. Hydr. and Civ. Engr., I. O. O. F. Blk., Madison, Me. (*Assoc. M., May 2, 1900*)	April 5, 1910
Humphreys, David Carlisle. Dean and Prof. of Civ. Eng., Washington and Lee Univ., Lexington, Va	Nov. 2, 1887
Hunt, Andrew Murray. Cons. Engr., Union Trust Bldg., San Francisco, Cal	Feb. 7, 1906
HUNT, CHARLES WARREN. (*Secretary*). 220 West 57th St. (Res., 171 West 88th St.), New York City	Jan. 2, 1884
Hunt, Conway Bethune. Engr. of Highways, District of Columbia, District Bldg. (Res., 2017 N St., N. W.), Washington, D. C	Feb. 4, 1891
Hunt, Robert Woolston. 1121 The Rookery, Chicago, Ill	June 3, 1885
Hunt, Rufus Cameron. Civ. Engr. and Contr., Washington Court House, Ohio	Oct. 5, 1904
Hunt, William Henry. Cons. Engr., 29 Broadway, New York City	June 30, 1911
Hunter, Adam. Chf. Engr. and Director, *Sir* William Arrol & Co., Ltd., 85 Preston St., Bridgeton, Glasgow, Scotland. (*Assoc. M., Sept. 6, 1905*)	May 2, 1911
Hunter, John Burnap. Engr. and Member of Board of Public Works, 351 Broadway, Denver, Colo	June 3, 1908
Hunter, Joseph Wray. State Highway Commr. of Pennsylvania, Jenkintown, Pa	May 3, 1910
Hunter, William. Chf. Engr., P. & R. Ry., Room 520, Reading Terminal, Philadelphia, Pa	June 5, 1895
Hunter, William Henry. 42 Spring Gardens, Manchester, England	Feb. 7, 1906
Hurry, Edward Henry. Llanover, Churt, Farnham, England	June 1, 1898
Huss, George Morehouse. Reserve, Wis	May 1, 1907
Hussey, Ernest Bertrand. 1011 Alaska Bldg., Seattle, Wash	July 1, 1908
Hutchings, William Evelyn. 1083 Cherokee Rd.. Louisville, Ky	June 7, 1899
Hutchins, Jere Chamberlain. Pres., Detroit United Ry., 12 Woodward Ave., Detroit, Mich. (*Assoc. M., Mar. 2, 1898*)	April 4, 1900
Hutchinson, Cary Talcott. Cons. Engr., 60 Wall St., New York City. (*Assoc. M., Mar. 4, 1896*)	Mar. 1, 1904
Hutchinson, George Hunt. Chf. Engr., North Western Fuel Co., Pioneer Press Bldg., St. Paul, Minn. (*Assoc. M., Sept. 2, 1891*)	June 7, 1893
Hyde, Abraham Lincoln. Asst. Prof. of Bridge Eng., Univ. of Missouri, Columbia, Mo. (*Assoc. M., April 5, 1893*)	Oct. 6, 1897
Hyde, Charles Gilman. San. and Hydr. Engr.; Prof. of San. Eng., Univ. of California, Civ. Eng. Bldg., Berkeley, Cal. (*Assoc. M., April 2, 1902*)	June 1, 1909
Hyde, Howard Elmer. Engr. in Chg., Design, Havana Sewerage and Drainage System, Jefatura del Alcantarillado, Calle Cuba No. 24, Havana, Cuba. (*Assoc. M., April 4, 1906*)	June 6, 1911
Inagaki, Hyotaro. Res. Engr., Imperial Govt. Ry., Ikegamimura Ebaragori, Tokyo, Japan. (*Assoc. M., Oct. 2, 1907*)	Oct. 31, 1911
Ingalls, Owen Lovejoy. Asst. Engr., Engr. Dept. at Large, War Dept., Manila, Philippine Islands. (*Jun., Mar. 5, 1890*)	June 4, 1902
Ingersoll, Colin Macrae, Jr. Advisory Engr., 165 Broadway, Room 2127, New York City	June 5, 1895
Irwin, James Clark. Chf. Engr., Rutland R. R., Rutland, Vt. (*Jun., April 4, 1893; Assoc. M., Dec. 7, 1898*)	June 6, 1900

	Date of Membership
Isaacs, John Dove. Cons. Engr., Harriman Lines, 165 Broadway, New York City	Mar. 7, 1894
Ives, Arthur Stanley. Cons. Engr., 9 Adriance Ave., Poughkeepsie, N. Y. *(Jun., Jan. 7, 1896; Assoc. M., Jan. 3, 1900)*	May 7, 1902
Jackson, Dugald Caleb. Prof. of Elec. Eng., Mass. Inst. Tech.; Cons. Engr. (D. C. & Wm. B. Jackson), 84 State St., Boston Mass.	Nov. 2, 1898
Jackson, Thomas Herbert. Capt., Corps of Engrs., U. S. A., U. S. Engr. Office, Dallas, Tex	Mar. 4, 1908
Jackson, Thomas Moore. Pres., West Va. Short Line R. R., Clarksburg, W. Va	June 3, 1891
Jackson, William Benjamin. (D. C. & Wm. B. Jackson), 111 West Monroe St., Chicago, Ill.	Mar. 4, 1903
Jacob, Thomas Nottingham. Chf. Engr., East Side Levee and San. Dist., 205 Sexton Bldg., East St. Louis, Ill.	May 4, 1909
Jacobs, Charles Mattathias. 30 Church St., New York City	May 4, 1904
Jacobs, Joseph. Cons. Engr., 406 Central Bldg., Seattle, Wash. *(Assoc. M., Sept. 4, 1901)*	April 6, 1909
Jacobsen, Hans Petter Rude. Cons. Engr., Oyster Bay, N. Y.	May 3, 1910
Jacomb-Hood, John Wykeham. Chf. Engr., Lond. & S. W. Ry., Engr.'s Office, Waterloo Station, London, S. E., England	Feb. 5, 1902
James, William Atlee. Div. Engr. of Constr., C. P. Ry., 151 Lenore St., Winnipeg, Man., Canada	July 1, 1909
Jameson, Charles Davis. Superv. Engr. and Archt. to the Imperial Chinese Board of Foreign Affairs (Wai Wu Pu), Peking, China	Mar. 7, 1888
Jamieson, James Alexander. Cons. and Designing Engr., Board of Trade Bldg., Montreal, Que., Canada	May 3, 1905
Jamieson, John Quintin. 475 Hassalo St., Portland, Ore.	Nov. 6, 1889
Janes, George Portlock. 405 Third Ave., East, Roselle, N. J.	May 1, 1907
Janney, William Dean. 2109 Homewood Ave., Baltimore, Md.	April 1, 1896
Janvrin, Ned Herbert. Asst. Engr., Board of Water Supply, City of New York, 201 Liberty St., Newburgh, N. Y. *(Jun., Oct. 5, 1897; Assoc. M., June 5, 1901)*	April 4, 1911
Japp, Henry. S. Pearson & Son, Inc., 507 Fifth Ave., New York City	May 3, 1905
Jaques, William Henry. Counselling Engr.; Pres., Hampton Water-Works Co.; Vice-Pres. and Gen. Mgr., United Telephone Co., Board of Trade Bldg., Boston, Mass	July 2, 1890
Jarrett, Edwin Seton. Vice-Pres. and Treas., The Foundation Co., 115 Broadway, New York City. *(Assoc. M., May 1, 1895)*	April 6, 1909
Jarvis, Charles Maples. Pres., Am. Hardware Corporation, New Britain, Conn.	Jan. 7, 1885
Jaudon, Henry Scudder. Cons. Engr., Savannah Water-Works System, P. O. Box 582, Savannah, Ga. *(Assoc. M., Feb. 4, 1903)*	Feb. 1, 1910
Jaycox, Thomas William. Cons. Engr., Foster Bldg., Denver, Colo.	Jan. 4, 1882
Jeme, Tien Yow. Chf. Director and Chf. Engr., Imperial Peking-Kalgan Ry. and Associate Director, Ichang-Wanhsien Sec., Szechuan Chuenhan Ry., Peking, China	Nov. 30, 1909
Jenckes, Lawrence Bates. 46 Fruit St., Worcester, Mass. *(Jun., Mar. 31, 1891; Assoc. M., Oct. 7, 1896)*	Sept. 6, 1910
Jenkins, William Dunbar. Engr. and Supt. of Constr. of Hamilton National Bank Bldg., Chattanooga, Tenn.	Sept. 7, 1887
Jervey, Henry. Maj., Corps of Engrs., U. S. A., U. S. Engr. Office, Custom House, Cincinnati, Ohio	June 5, 1907
Jervey, James Postell. Maj., Corps of Engrs., U. S. A., Gatun, Canal Zone, Panama	Nov. 1, 1910
Jewel, Lindsey Louin. Mgr. of Erection, McClintic-Marshall Constr. Co., Gatun, Canal Zone, Panama. *(Assoc. M., April 4, 1906)*	Nov. 1, 1910
Jewett, William Cornell. Res. Engr., The Board of Hospital Commrs. (Res., 541 Ridgeway Ave.), Cincinnati, Ohio	June 3, 1885
Johnson, Albert Lincoln. First Vice-Pres., Corrugated Bar Co., Mutual Life Bldg., Buffalo, N. Y. *(Assoc. M., Sept. 2, 1896)*	Dec. 4, 1901
Johnson, Arthur Newhall. State Highway Engr., Springfield, Ill. *(Assoc. M., Sept. 2, 1903)*	July 1, 1909
Johnson, Ben. Supt. of Locks at Gatun, Gatun, Canal Zone, Panama	June 6, 1911
Johnson, Chapman Love. Cons. Engr., 238 Mary St., Utica, N. Y.	Oct. 7, 1903
Johnson, Francis Robert. Vernon, B. C., Canada	June 1, 1898
Johnson, James Moreland. Engr. and Pres., Louisville Bridge & Iron Co., Louisville, Ky.	July 1, 1891
Johnson, Lewis Elisha. Asst. to Supt., B. and C. Dept., The Pennsylvania Steel Co., Steelton, Pa. *(Assoc. M., Nov. 4, 1896)*	May 1, 1901
Johnson, Lewis Jerome. Prof. of Civ. Eng., Harvard Univ., and Cons. Engr., 309 Pierce Hall, Cambridge, Mass. *(Assoc. M., Sept. 4, 1901)*	Nov. 1, 1904
Johnson, Lucien Samuel. U. S. Engr. Office, Louisa, Ky.	Dec. 4, 1901

	Date of Membership
Johnson, Phelps. Mgr., Dominion Bridge Co., Ltd., Windsor Hotel, Montreal, Que., Canada	July 1, 1891
Johnson, Thomas H. Cons. Engr., 720 Union Station, Pittsburgh, Pa.	Sept. 5, 1877
Johnson, William Stone. San. and Hydr. Engr., 101 Tremont St., Boston, Mass. (*Assoc. M., June 6, 1894*)	May 1, 1906
Johnston, Albert William. Gen. Mgr., The N. Y., C. & St. L. R. R., 424 Hickox Bldg., Cleveland, Ohio	Mar. 6, 1895
Johnston, Clarence Thomas. Prof. in Surveying, Eng. Dept., Univ. of Michigan, Ann Arbor, Mich.	Sept. 7, 1904
Johnston, Horace Greeley. Pres. and Gen. Mgr., The Am. Well & Prospecting Co., Corsicana, Tex.	Sept. 7, 1887
Johnston, John Albert. Div. Engr., Mass. Highway Comm., 65 Knowles Bldg., Worcester, Mass.	Feb. 6, 1912
Johnston, John Howard. Casapalca, Boulevard Cimiez, Nice, Alpes Maritimes, France	Mar. 1, 1876
Jonah, Frank Gilbert. Chf. Engr. of Constr., St. L. & S. F. R. R., Frisco Bldg., St. Louis, Mo.	Nov. 4, 1903
Jonas, Henry F. Asst. Engr., M. of W., Sunset Lines, Texas and Louisiana, P. O. Box 583, Houston, Tex.	Oct. 2, 1907
Jones, Arthur Lewis. Apartado No. 193, City of Mexico, D. F., Mexico.	July 10, 1907
Jones, Howard Murfree. Cons. Engr., Room 407, Cole Bldg., Nashville, Tenn.	June 1, 1909
Jones, William Henry. Prin. Asst. Engr., Mo. Val. Bridge & Iron Co., 315 Vine St., Leavenworth, Kans.	May 4, 1904
Jordan, Edward Clarence. Civ. and Hydr. Engr., 31½ Exchange St., Portland, Me.	May 7, 1890
Jordán, Ricardo Tomás. Jefe, 7ª Zona de Ferrocarriles, Edificio de Faros, Vera Cruz, Ver., Mexico	Oct. 4, 1910
Judd, Wilber Macaulay. Engr. and Archt. (The W. G. Wilkins Co.), Westinghouse Bldg., Pittsburgh, Pa.	Oct. 4, 1905
Judson, Charles Albert. Collector of Customs, Sandusky, Ohio	Jan. 3, 1894
Judson, William Pierson. Cons. Engr., Broadalbin, Fulton, Co., N. Y.	Sept. 7, 1881
Judson, William Voorhees. Maj., Corps of Engrs., U. S. A., District Bldg., Washington, D. C.	Nov. 4, 1896
Juengst, Henry Frederick. Care, City Water-Works, Chattanooga, Tenn.	April 2, 1884
Just, George Alexander. Cons. Engr.; Pres., The Geo. A. Just Co., 239 Vernon Ave., Long Island City, N. Y. (*Jun., Sept. 3, 1884*)	Mar. 4, 1891
Kadono, Chokuro. Engr. and Director, Okura & Co., Tokyo, Japan	Jan. 8, 1902
Kafka, Frederick Percival. Pres. and Mgr., Herringbone Metal Lath Co., 257 East 133d St., New York City (Res., 49 Washington Ave., New Rochelle, N. Y.). (*Assoc. M., May 1, 1907*)	Jan. 2, 1912
Kareischa, Serge de. Director and Prof. of the Imperial Inst. of Engrs. of Ways and Communications; Pres., Assoc. of M. of W. Engrs., Russian Ry., Zabalkansky prospect No. 9, log. 1, St. Petersburg, Russia	June 6, 1894
Kastl, Alexander Edward. Special Deputy State Engr., Barge Canal Office, Albany, N. Y. (*Jun., Jan. 4, 1888*)	Nov. 5, 1890
Katté, Walter. The Ramondo, 784 Park Ave., New York City	Oct. 7, 1868
Kauffmann, William Frederick. Asst. Engr., N. Y. C. & H. R. R. R., 50 Lincoln Pl., East Rutherford, N. J.	Sept. 6, 1905
Kaufman, Gustave. Engr. and Mgr., The Wilson & Baillie Mfg. Co., 26 Court St., Brooklyn, N. Y.	May 7, 1890
Keating, Edward Henry. Cons. Engr. (Keating & Breithaupt), 82 King St., E., Toronto, Ont., Canada	June 7, 1882
Keefer, Charles Henry. 49 Metcalf St., Ottawa, Ont., Canada	Oct. 7, 1908
KEEFER, THOMAS COLTRIN. (*Past-President*). Ottawa, Ont., Canada.	April 4, 1877
Keith, George Thomas. Res. Engr., Impvt. of Public Highways, Olean, N. Y.	May 4, 1881
Keith, Herbert Cary. Cons. Engr., 116 Nassau St., New York City	Dec. 4, 1889
Keller, Charles. Maj., Corps of Engrs., U. S. A., U. S. Engr. Office, Rock Island, Ill.	Mar. 7, 1900
Keller, Charles Lincoln. First Asst. Engr., The Scherzer Rolling Lift Bridge Co., 1616 Monadnock Blk., Chicago, Ill. (*Jun., Oct. 4, 1898; Assoc. M., Mar. 6, 1901*)	Oct. 31, 1905
Kelley, Howard George. Vice-Pres., G. T. Ry. System, Montreal, Que., Canada	May 1, 1889
Kelley, James Augustus. Andes, Delaware Co., N. Y. (*Assoc. Mar. 5, 1901; Assoc. M., Sept. 2, 1903*)	Mar. 3, 1908
Kelley, William Datus. Pres., Kelly & Kelley (Inc.), Engrs., Builders and Contrs., 12th St., near Vernon Ave., Long Island City, N. Y.	Nov. 2, 1887
Kellogg, Charles. Athens, Pa.	June 2, 1880
Kellogg, Norman Benjamin. Cons. Engr., San Diego, Cal. (*Jun., Feb. 6, 1878*)	July 3, 1895
Kelly, Cassius William. City Engr., 17 City Hall, New Haven, Conn. (*Jun., Mar. 1, 1882*)	June 6, 1888

	Date of Membership
Kelsey, Louis Curtis. Civ. and Hydr. Engr., 404 Selling Bldg., Portland, Ore.	Mar. 2, 1909
Kendall, Charles Hanford. Rushford, N. Y.	Nov. 6, 1907
Kendrick, John William. Care, Outing Publishing Co., 141 West 36th St., New York City	June 6, 1883
Kendrick, Julian Way. First National Bank Bldg., Birmingham, Ala.	Oct. 1, 1902
Kennedy, James Henry. Asst. Chf. Engr., Vancouver, Victoria & East. Ry. & Nav. Co., G. N. Ry. Depot, Vancouver, B. C., Canada	May 2, 1900
Kennedy, Jeremiah Joseph. Cons. Engr., 52 Broadway, New York City	June 4, 1902
Kennedy, John. Cons. Engr., Harbor Commrs., 57 Common St., Montreal, Que., Canada	Sept. 1, 1875
Kennedy, William Harlin. 400 Atlantic Ave., Pittsburgh, Pa.	Sept. 6, 1871
Kenney, Edward Fulbister. Metallurgical Engr., Cambria Steel Co., Johnstown, Pa. (*Jun., Nov. 3, 1896; Assoc. M., May 3, 1899*)	April 3, 1906
Kenrick, Robert Boteler. Care, Dominion Bridge Co., Montreal, Que., Canada	July 9, 1906
Kent, Willard. Narragansett Pier, R. I.	Oct. 2, 1907
Kernot, Maurice Edwin. Chf. Engr. for Ry. Constr., Victorian Rys., Ry. Dept., Spencer St., Melbourne, Victoria, Australia	June 5, 1907
Kerr, Frank Montgomery. Chf. State Engr. of Louisiana, New Orleans Court Bldg., New Orleans, La.	Oct. 2, 1901
Kerr, Halbert Stevens. Manti, Utah	Feb. 5, 1908
Kerr, Luther Yager. U. S. Engr. Office, Custom House, Memphis, Tenn.	June 4, 1902
Ketchum, Milo Smith. Dean, Coll. of Eng. and Prof. of Civ. Eng., Univ. of Colorado; Cons. Engr., Boulder, Colo. (*Assoc. M., Sept. 4, 1901*)	Mar. 3, 1908
Ketchum, Richard Bird. Assoc. Prof. of Civ. Eng., Univ. of Utah, Salt Lake City, Utah	June 5, 1907
Khuen, Richard. Res. Engr., Am. Bridge Co., Pittsburgh, Pa. (*Jun., Dec. 3, 1891; Assoc. M., May 1, 1895*)	Nov. 2, 1898
Kibbe, Augustus Sayre. Cons. Engr., 1049 Sierra St., Reno, Nev. (*Jun., Mar. 6, 1889*)	Aug. 31, 1909
Kieffer, Stephen Ephraim. Cons. Engr., 805 Mechanics Inst. Bldg., San Francisco, Cal. (*Assoc. M., Oct. 5, 1904*)	Jan. 3, 1907
Kielland, Soren Theodor Munch Bull. Civ. Engr., Buffalo Creek R. R.; V. Consul of Norway, 364 Ellicott Sq., Buffalo, N. Y.	Feb. 6, 1889
Kiersted, Wynkoop. Cons. Engr., 58 Water-Works Bldg., Kansas City, Mo.	Oct. 5, 1887
Kimball, Frank Clifton. Civ. and Hydr. Engr., 14 Beacon St., Boston, Mass.	June 3, 1903
KIMBALL, GEORGE ALBERT. (*Director*). Chf. Engr., Elev. Subway Constr., Boston Elev. Ry., 101 Milk St., Boston, Mass. (*Jun., May 12, 1875*)	July 1, 1891
Kimball, George Henry. Cons. Engr., 1332 Penobscot Bldg., Detroit, Mich.	Dec. 3, 1890
Kimball, Herbert Sawyer. Mill Archt. and Engr., 46 Cornhill, Boston, Mass.	Nov. 1, 1910
Kimball, William Hale. 206 Mississippi Ave., Davenport, Iowa. (*Assoc. M., April 1, 1903*)	Jan. 31, 1911
King, Paul Sourin. Cons. Engr., 3034 North 15th St., Philadelphia, Pa.	July 3, 1889
King, William Byrd. Gen. Mgr., Fort Worth Stock Yards Co. and Fort Worth Belt Ry., Fort Worth, Tex.	Oct. 7, 1896
King, Winfield Scott. 2311 G St., South Omaha, Nebr.	Dec. 6, 1899
Kingsley, Marvin Watson. Civ. and Hydr. Engr., 823 Rose Bldg., Cleveland, Ohio	July 3, 1878
Kinnear, Wilson Sherman. Pres., Kansas City Terminal Ry., 311 First National Bank Bldg., Kansas City, Mo.	July 9, 1906
Kinsley, Thomas Pearson. 185 Audubon Ave., New York City	Feb. 5, 1873
Kirkpatrick, Walter Gill. Cons. Municipal and Hydr. Engr., Jackson, Miss. (*Assoc. M., April 6, 1892*)	Oct. 5, 1898
Kitchin, John William. Care, Para Constr. Co., Ltd., 9 Rue Louis le Grand, Paris, France	Jan. 31, 1911
Kittredge, George Watson. Chf. Engr., N. Y. C. & H. R. R. R., N. J. Shore Line Ry., Terminal Ry. of Buffalo, Grand Central Terminal, New York City	Jan. 6, 1886
Kittrell, James Wesson. Catskill, N. Y.	Sept. 1, 1897
Klapp, Eugene. Cons. Engr. (Barclay Parsons & Klapp), 60 Wall St., New York City	Feb. 6, 1901
Kleinbeck, August Gustave. Litchfield, Ill.	Feb. 3, 1897
Klinck, John Henry. Industrial and Power Dept., Westinghouse Elec. & Mfg. Co., 308 Am. Bldg., Charlotte, N. C.	June 3, 1908
Kluegel, Charles Henry. Chf. Engr., Hilo R. R., Hilo, Hawaii	Oct. 1, 1902
KNAP, JOSEPH MOSS. (*Treasurer*). 220 West 57th St., New York City.	April 5, 1882
Knapp, Hermann Meriwether. Contr. Mgr., Am. Bridge Co. of N. Y., Union Trust Bldg., Cincinnati, Ohio. (*Assoc. M., May 6, 1903*)	Jan. 31, 1905
Knapp, Louis Henry. Civ. and Hydr. Engr., 280 Linwood Ave., Buffalo, N. Y.	Mar. 4, 1874
Knapp, Zac Ellis. Engr., Underground Elec. Rys., Ltd.; Mgr., London United Tramways, Ltd., 74 High Rd., Chiswick, London, W., England.	Dec. 5, 1906

	Date of Membership
Knickerbacker, John. Pres., Eddy Valve Co., Waterford, N. Y.	Jan. 2, 1900
Knickerbocker, Curtis Edwin. Care, MacDonald Constr. Co., 149 Broadway, New York City	Feb. 1, 1905
Knight, Charles William. Rome, N. Y.	July 9, 1906
Knight, Herbert Miller. Engr. for The M. A. Talbott Co. of Baltimore, Md.; Res., 205 West Garden St., Rome, N. Y.	May 3, 1910
Knight, Richard Warren. Contr. Engr., McClintic-Marshall Constr. Co., Oliver Bldg., Pittsburgh, Pa.	Feb. 2, 1909
Knight, Walter Harris. Care, International Power Co., 165 Broadway, New York City	Feb. 1, 1893
Knighton, John Albert. Asst. Engr., Dept. of Bridges; Engr., East River Bridges, Park Row Bldg., New York City	Jan. 4, 1905
Knobloch, Walstan Emile. U. S. Asst. Engr., Third Floor, Metropolitan Bank Bldg., New Orleans, La.	Oct. 2, 1907
Knowles, Morris. Cons. Engr., 2548 Oliver Bldg., Pittsburgh, Pa. *(Jun., Oct. 4, 1892; Assoc. M., Jan. 1, 1896)*	April 1, 1903
Knowlton, Theodore Ely. Cons. Engr., 63 Wall St., New York City. *(Assoc., Mar. 31, 1896; Assoc. M., May 7, 1902)*	Sept. 1, 1908
Knox, Samuel Lippincott Griswold. Vice-Pres. and Chf. Engr., Hammon Eng. Co., 311 California St., San Francisco, Cal.	July 10, 1907
Knox, Schuyler Brush. Eastern Mgr. and Contr. Engr., Fort Pitt Bridge Works, 45 Broadway, New York City	Nov. 8, 1909
Kondo, Sentaro. Doboku Shitchojo, Naimusho, Tokyo, Japan	Nov. 7, 1900
Kondo, Toragoro. Chf. Inspecting Engr., Home Dept., Tokyo, Japan. *(Jun., Oct. 3, 1888)*	June 5, 1901
Kops, Julian de Bruyn. Civ. Engr. and Archt., 27 Bay St., East, Savannah, Ga. *(Assoc. M., April 4, 1894)*	Jan. 5, 1904
Kower, Hermann. East Hall, Univ. of California, Berkeley, Cal.	Oct. 5, 1904
Krome, William Julius. Const. Engr., Key West Extension, Fla. East Coast Ry., Marathon, Fla.	Oct. 3, 1911
Kuersteiner, Emil Edward. Bridge Engr., L. & N. R. R., 1274 South Floyd St., Louisville, Ky.	Dec. 1, 1897
Kuichling, Emil. Cons. Engr., 52 Broadway, New York City	Sept. 3, 1884
C. Kummer, Frederic Arnold. Cons. Engr., 26 South St., Baltimore, Md. *(Jun., April 30, 1895; Assoc. M., Mar. 4, 1903)*	Oct. 2, 1906
Kunz, Frederic Charles. Cons. Engr., Osborne and Vicaris Sts., Wissahickon, Philadelphia, Pa. *(Assoc. M., Feb. 6, 1895)*	Dec. 7, 1898
Kurashige, Tetsuzo. Care, Inawashiro Suiryoku-Denki Kaisha, No. 1 Ichome Yurakucho, Kojimachi, Tokyo, Japan	May 2, 1911
Kutz, Charles Willauer. Maj., Corps of Engrs., U. S. A., Manila, Philippine Islands	May 7, 1902
Kwong, King Yang. Engr.-in-Chf., Imperial Peking-Kalgan Ry., Kalgan, North China	April 1, 1908
Labelle, Henry Francis. Cons. Hydr. Engr., 720 South Arno St., Albuquerque, N. Mex.	April 6, 1898
La Chicotte, Henry Arthur. Deputy Chf. Engr., Dept. of Bridges, City of New York, 21 Park Row, New York City	Oct. 3, 1894
Lackey, Oscar Francis. Harbor Engr., Baltimore, Md. *(Assoc. M., May 4, 1904)*	April 6, 1909
LaForge, Frederick William. U. S. Asst. Engr., Care, U. S. Engr. Office, New London, Conn.	Oct. 5, 1904
Lahmer, John Aloysius. 1214 East 34th St., Kansas City, Mo.	June 3, 1908
Lake, Edward Nelson. Stone & Webster Eng. Corporation, 147 Milk St., Boston, Mass.	July 1, 1909
Lall, Chiranji. Head Master, Govt. School of Eng., Nila Gumbad, Mool Chand St., Lahore, Punjab, India	Oct. 5, 1909
Lamb, Richard. Cons. and Const. Engr., 136 Liberty St., Room 528, New York City. *(Assoc. M., May 6, 1891)*	June 6, 1900
Landon, Eugene Ashbel. Secy. and Treas., Begent Lumber Co., Groton, N. Y.	April 1, 1896
Landor, Edward John. Contr. Engr., 1013 N. Walnut St., Canton, Ohio.	Mar. 7, 1888
Landreth, Olin Henry. Prof. of Eng., Union Coll.; Cons. Engr., Schenectady, N. Y.	Sept. 3, 1884
Landreth, William Barker. Cons. Engr., 20 Gillespie St., Schenectady, N. Y.	Oct. 3, 1888
Lane, Harry Alfred. Asst. Engr., Surveys, B. & O. R. R., B. & O. Bldg., Baltimore, Md. *(Assoc. M., Feb. 1, 1905)*	Mar. 1, 1910
Lang, Otto Heinrich. Archt. and Structural Engr. (Lang & Mitchell), 622 Wilson Bldg., Dallas, Tex.	Oct. 5, 1904
Lange, Gunardo Anfin. Colonia Alvear, Prov. de Mendoza, Argentine Republic	Mar. 3, 1897
Langthorn, Jacob Stinman. Div. Engr., Board of State Water Supply, 250 West 54th St., New York City	Jan. 4, 1905
Langton, John. Cons. Engr., 31 Nassau St., New York City	May 2, 1900

	Date of Membership
Lant, Frank Parsons. 135 Broadway (Res., 548 West 124th St.), New York City. (*Jun., Oct. 3, 1888*)	Feb. 1, 1910
Larrabee, William Dominick. Cons. Engr., 910 West 16th St., Los Angeles, Cal.	Oct. 5, 1904
Larsson, Carl Gustaf Emil. Asst. Chf. Engr., Am. Bridge Co. of N. Y., 9 Rockview Terrace, Plainfield, N. J.	April 1, 1903
Latey, Harry Nelson. Cons. Engr., 100 Broadway, New York City	June 6, 1906
Lathbury, Benjamin Brentnall. 608 Vernon Rd., Germantown, Philadelphia, Pa. (*Assoc. M., Mar. 3, 1897*)	June 6, 1905
Latta, Harrison Wainwright. Pres., Latta & Terry Constr. Co., 1319 Pennsylvania Bldg., Philadelphia, Pa. (*Assoc. M., Sept. 5, 1900*)	April 4, 1905
Laub, Hermann. Cons. Engr., 610 Lewis Bldg., Pittsburgh, Pa.	Sept. 1, 1897
Lavelle, Thomas Monahan. Engr. with The Eastern Steel Co., Pottsville, Pa. (*Assoc. M., Sept. 7, 1904*)	June 30, 1911
Lavis, Fred. Cons. Engr., 50 Church St., New York City. (*Assoc. M., Sept. 6, 1899*)	Sept. 4, 1906
Lawlor, Francis Denis Hubert. Citizens Water Co., Burlington, Iowa. (*Jun., Oct. 6, 1886*)	Mar. 6, 1895
Lawrence, Edgar Heisler. Structural Engr., Marshall & Fox, 919 First National Bank Bldg., Chicago, Ill.	Oct. 5, 1909
Lawson, Thomas R. William Howard Hart Prof. of Rational and Technical Mechanics, Rensselaer Polytechnic Inst., 105 Eighth St., Troy, N. Y. (*Assoc. M., June 3, 1903*)	Jan. 3, 1907
Lawton, William Henry. City Engr., 24 Bellevue Ave., Newport, R. I.	June 2, 1886
Layfield, Elwood Norman. Chairman, Grand Rapids Grade Separation Comm., 535 Houseman Bldg., Grand Rapids, Mich.	June 5, 1907
Layton, Hudson Flack. Cons. Engr., Oliver Bldg., Pittsburgh, Pa.	Nov. 30, 1909
Lea, Allan Benjamin. Araoz 2854, Buenos Aires, Argentine Republic	Mar. 4, 1908
Lea, Richard Smith. 405 Dorchester St., West, Montreal, Que., Canada	July 1, 1908
Lea, Samuel Hill. State Engr. of South Dakota, State Capitol, Pierre, S. Dak.	Nov. 3, 1897
Lea, Sumter, Jr. 222 Seventy-third St., North, Birmingham, Ala.	Mar. 4, 1908
Leavenworth, George Stevens. Chf. Engr., Powers & Mansfield Co., 251 River St., Troy, N. Y. (*Assoc. M., June 3, 1903*)	Feb. 5, 1907
Leavitt, Charles Wellford, Jr. Civ. and Landscape Engr., 220 Broadway, New York City. (*Assoc. M., Jan. 4, 1898*)	May 2, 1905
Leavitt, Erasmus Darwin. 33 Garden St., Cambridge, Mass.	July 2, 1873
Leavitt, Frank McDowell. Cons. Engr. to E. W. Bliss Co., 133 Plymouth St., Brooklyn, N. Y.	Dec. 2, 1885
LeBaron, John Francis. Cons. Engr., Chardon, Ohio	June 7, 1882
LeConte, Louis Julian. 2501 Piedmont Ave., Berkeley, Cal.	April 4, 1877
Ledlie, Charles Hees. Cons. Engr., 918 Rialto Bldg., St. Louis, Mo.	Jan. 4, 1888
Ledoux, John Walter. Chf. Engr., The Am. Pipe Mfg. Co., 112 North Broad St., Philadelphia, Pa.	June 5, 1895
Lee, David Read. 12 Lake Ave., Middletown, N. Y. (*Assoc. M., Oct. 7, 1896*)	Nov. 1, 1910
Lee, Edward Hervey. Chf. Engr., Chi. & W. Ind. R. R. and The Belt Ry. of Chicago, Room 45, Dearborn Station, Chicago, Ill.	June 6, 1900
Lee, Francis Valentine Toldervy. Care, Royal Colonial Inst., Northumberland Ave., London, W. C., England	Feb. 1, 1910
Lee, Frank. Div. Engr., C. P. Ry., Winnipeg, Man., Canada	May 2, 1911
Lee, Wellington Barnes. 30 Church St., New York City. (*Assoc. M., Feb. 5, 1896*)	May 4, 1898
Lee, William States. Chf. Engr., Southern Power Co., Charlotte, N. C.	Oct. 4, 1905
Leffingwell, Frank Dodge. 460 Bloomfield Ave., Montclair, N. J. (*Assoc. M., Oct. 5, 1898*)	Dec. 5, 1905
Leffingwell, William Howland. Chf. Engr., Mono Power Co., Bishop, Inyo Co., Cal.	Oct. 4, 1893
Leffler, Burton Rutherford. Engr. of Bridges, L. S. & M. S. Ry., 1515 East 86th St., Cleveland, Ohio. (*Assoc. M., April 6, 1904*)	Sept. 6, 1910
Legaré, Balie Peyton. Chf. Engr., United Railroads of San Francisco, 85 Second St., San Francisco, Cal.	July 10, 1907
Leh, Elvin Ulysses. Supt., Cowell Portland Cement Co.'s Plant, Cowell, Cal., *via* Bay Point	May 31, 1910
Lehlbach, Gustav. 196 Market St., Newark, N. J.	Mar. 7, 1883
Lehman, George Mustin. Engr. in Chg., Flood Comm., 1805 Arrott Bldg., Pittsburgh, Pa.	May 2, 1911
Lehnartz, Frederick William. Siebengebirgs Allee 14, Klettenberg, Cologne, Germany	Aug. 6, 1879
Leidy, George Craig. Asst. Supt., Semet Solvay Co., Steelton, Pa.	June 30, 1911
Leighton, George. Res. Engr., D., L. & W. R. R., Andover, N. J.	Oct. 3, 1906
Leighton, Marshall Ora. Chf. Hydrographer, U. S. Geological Survey (Res., 4200 Sixteenth St., N. W.), Washington, D. C. (*Assoc., M., Oct. 4, 1905*)	Feb. 28, 1911
Leisen, Theodore Alfred. Cons. Engr.; Chf. Engr. and Supt., Louisville Water Co., Louisville, Ky.	June 2, 1897

	Date of Membership
Leitch, John. Res. Engr., East Indian Ry., Bankipore, Bengal, India	Dec. 5, 1911
Leland, George Herbert. 930 Banigan Bldg., Providence, R. I. (*Jun., Mar. 2, 1887*)	Feb. 1, 1893
Leland, Ora Miner. Asst. Prof., Coll. of Civ. Eng., Cornell Univ., and Member, Comm. of Engrs., Costa Rica-Panama Boundary Arbitration, Cascadilla Bldg., Ithaca, N. Y. (*Assoc. M., Feb. 1, 1905*)	Mar. 1, 1910
Leland, Warren Allston. Chf. Engr., Yadkin River Power Co., Rockingham, N. C	Oct. 3, 1900
Lentilhon, Eugene. Cons. Engr., 37 West 44th St., New York City. (*Jun., Mar. 1, 1891; Assoc. M., Mar. 6, 1895*)	Feb. 6, 1906
Leonard, Clifford Milton. Pres. and Treas., Canadian Leonard Constr. Co., Ltd., and Leonard Constr. Co., 1937 McCormick Bldg., Chicago, Ill. (*Assoc. M., Oct. 2, 1907*)	May 31, 1910
Leonard, Henry Read. Engr. of Bridges and Bldgs., P. R. R., Broad St. Station, Philadelphia, Pa	April 4, 1894
Leonard, James Augustus. Asst. Engr., Ambursen Hydr. Constr. Co., 88 Pearl St., Boston, Mass	April 1, 1908
Leonard, John Buck. Cons. Engr., 313 Sheldon Bldg., San Francisco, Cal.	June 1, 1909
Lepper, Fred William. 97 Carlyon Rd., East Cleveland, Ohio. (*Assoc., M., Jan. 2, 1901*)	Feb. 6, 1906
Lewinson, Maxymilian. 128 West 42d St., New York City	Feb. 7, 1894
Lewis, Clarence Charles. Mgr., Cordoba Office, J. G. White & Co., Ltd., Cordoba, Argentine Republic	Feb. 6, 1907
LEWIS, EUGENE CASTNER. (*Director*). Chairman, Board of Directors, N., C. & S. L. Ry.; Pres., The American Co., Nashville, Tenn	Mar. 5, 1873
Lewis, Everett Wilson. Locating Engr., N. Y., N. H. & H. R. R., New Haven, Conn	Sept. 4, 1901
Lewis, Frederick Humphreville. 732 Brown-Marx Bldg., Birmingham, Ala	Jan. 6, 1897
Lewis, Marcus Winfield. U. S. Asst. Engr., Office, Chf. of Engrs., U. S. A., War Dept., Washington, D. C	June 5, 1907
Lewis, Nelson Peter. Chf. Engr., Board of Estimate and Apportionment, 277 Broadway, New York City	Oct. 2, 1895
Lewis, Sidney Francis. Chf. Engr., Orleans Levee Board, Suite 201, New Orleans Court Bldg., New Orleans, La	May 4, 1881
Lewis, William Willett. Asst. Engr., Boston Transit Comm., 15 Beacon St. (Res., 14 Albion St.), Boston, Mass	April 5, 1910
Lieb, John William, Jr. Third Vice-Pres. and Assoc. Gen. Mgr., The New York Edison Co., 55 Duane St., New York City	Oct. 5, 1898
Lilly, George Washington. Chf. Engr., St. Helens Public Service Co., 606 Marquam Bldg., Portland, Ore. (*Assoc. M., April 2, 1902*)	Jan. 31, 1905
R. Lindenthal, Gustav. Cons. Engr., 45 Cedar St., New York City	May 3, 1882
Lindsey, John Brown, Jr. Supt., West Pascagoula Creosoting Works, Gautier, Jackson Co., Miss. (*Assoc. M., June 3, 1903*)	Oct. 5, 1909
Linton, Harvey. Cons. Engr., 1717 Thirteenth St., Altoona, Pa	Oct. 5, 1892
Lippincott, Joseph Barlow. Asst. Chf. Engr., Los Angeles Aqueduct, 1108 Central Bldg., Los Angeles, Cal	Dec. 6, 1899
Lipsey, Thomas Eugene Leard. Asst. Engr., Dept. of Constr. and Eng., Isthmian Canal Comm., Culebra, Canal Zone, Panama. (*Assoc. M., April 6, 1904*)	Oct. 2, 1906
List, Charles. 302 Williams Bldg., San Francisco, Cal	June 3, 1903
Livingston, Archibald Rogers. Supt., The Empire Zinc Co., Cañon City, Colo	April 3, 1907
Llewellyn, Francis John. Div. Contr. Mgr., Am. Bridge Co. of N. Y., 1316 Commercial National Bank Bldg., Chicago, Ill	Nov. 4, 1896
Llewellyn, Frederick Thomas. With Carnegie Steel Co., 30 Church St., New York City. (*Assoc. M., Oct. 4, 1899*)	May 1, 1906
Lochridge, Elbert Emerson. Chf. Engr., Water Dept., 121 Bridge St., Springfield, Mass. (*Assoc. M., May 3, 1905*)	June 6, 1911
Locke, Charles Abbott. 1805 Belmont Circle, Nashville, Tenn	Oct. 3, 1888
Locke, Franklin Buchanan. Commr. of Public Works, North Adams, Mass	Mar. 1, 1893
Lockwood, James Button Clyde. 271 North East 9th St., Portland, Ore.	Mar. 6, 1901
Lockwood, Judd Allen. Asst. Engr., Dept. of Bridges, 428 East 133d St., New York City	April 4, 1899
Lockwood, Willard Datus. 23 Walnut Ave., Rockville Center, N. Y. (*Jun., April 3, 1894; Assoc. M., Oct. 7, 1896*)	Oct. 2, 1906
Lockwood, William Frederick. Engr., M. of W., Interborough Rap. Trans. Co., 165 Broadway, New York City	Oct. 4, 1910
Loe, Eric Haldorson. Archt. and Engr., Russell Miller Milling Co., Minneapolis, Minn	Feb. 1, 1910
Long, Maurice Alvin. Archt., B. & O. R. R., B. & O. R. R. Bldg., Baltimore, Md	Oct. 5, 1909
Look, Moses Jerome. Gen. Supt., MacArthur Bros. Co. and Winston & Co., Brown Station, N. Y. (*Assoc. M., May 6, 1903*)	April 4, 1905

		Date of Membership
	LOOMIS, HORACE. (*Director*). Cons. Engr. for Sewers, Office, Pres. of Borough of Manhattan, New York City	Nov. 5, 1879
	Loomis, Thomas Hooker. Cons. and Contr. Engr., 62 Capitol Ave., Hartford, Conn	Jan. 7, 1903
	Loree, Leonor Fresnel. 32 Nassau St. (Res., 247 Fifth Ave.), New York City	Oct. 6, 1886
	Lorraine, Madison Johnson. Willows, Glenn Co., Cal	Nov. 8, 1909
	Lothrop, Howard. Supt. and Engr. for Board of Park Commrs., 3320 North Main St., Fall River, Mass	June 6, 1911
	Lovell, Frederick William. Secy., The McMyler Interstate Co. (Res., 10008 Lamont Ave.), Cleveland, Ohio	June 6, 1906
	Lovell, Walter Danville. Cons. Engr., 1415 Eighth St., S. E., Minneapolis, Minn	May 4, 1904
N.	Low, Emile. U. S. Asst. Engr., 540 Federal Bldg., Buffalo, N. Y	May 2, 1888
	Lowe, Jesse. Civ. Engr. and Contr. (Christie & Lowe), 171 La Salle St., Chicago, Ill	Oct. 2, 1895
	LOWETH, CHARLES FREDERICK. (*Director*). Chf. Engr., C., M. & St. P. Ry., Room 1345, Railway Exchange, Chicago, Ill. (*Jun., Jan. 3, 1883*)	Feb. 6, 1884
	Lucas, Daniel Jones. Dept. of Public Works, Bureau of Surveys, Grade Crossing Div., Asst. Engr. in Chg. of Field Office, 2603 N. Broad St., Philadelphia, Pa. (*Jun., Sept. 6, 1876*)	July 4, 1888
	Lucas, Eugene Willett Van Court. Cons. Engr., 129 East 19th St., New York City. (*Assoc. M., April 3, 1895*)	Sept. 5, 1900
	Lucius, Albert. 38 Park Row, Room 607, New York City	Mar. 3, 1886
	Ludlow, Jacob Lott. Cons. Municipal, San. and Hydr. Engr., Winston-Salem, N. C	Mar. 3, 1897
	Lueder, Archibald Byron. Engr., Merrill-Ruckgaber Co., New York City, 31 Ridgedale Ave., Morristown, N. J	May 31, 1910
	Luiggi, Luigi. Insp. Gen., Royal Civ. Engrs.; Prof. of Maritime Constructions at the Royal School of Civ. Engrs., 81 Via Sardegna, Rome, Italy	Feb. 7, 1906
	Lum, David Walker. The Parker, 16th St. and Park Rd., Washington, D. C	May 3, 1893
	Lundie, John. Cons. Engr., 52 Broadway, New York City	July 4, 1888
	Lupfer, Alexander McClure. 1930 Eighth Ave., Spokane, Wash	Nov. 1, 1905
	Lupfer, Edward Payson. Cons. and Contr. Engr., 590 Ellicott Sq., Buffalo, N. Y	Jan. 3, 1906
	Luster, William Henry, Jr. City Surv., City Hall, Elizabeth, N. J. (*Assoc. M., Oct. 3, 1900*)	April 2, 1902
	Lydon, William Anthony. Pres., Great Lakes Dredge & Dock Co., Chamber of Commerce, Chicago, Ill. (*Jun., Jan. 4, 1888*)	Dec. 5, 1894
	Lyford, Oliver Smith, Jr. Cons. Engr., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City	May 6, 1908
	Lynch, Michael Lehane. 425 Hamilton Ave., Jackson, Miss	May 4, 1892
	Lyon, Henry Lloyd. Deputy Water Commr., Municipal Bldg., Buffalo, N. Y	Feb. 3, 1904
	Lyon, Léon Elie. Asst. U. S. Engr., U. S. Engr. Office, Norfolk, Va. (*Jun., Feb. 1, 1898; Assoc. M., April 4, 1900*)	June 5, 1906
	Lyons, James Knox. Pres., Gas Power Eng. Corporation, Empire Bldg., Pittsburgh, Pa. (*Assoc. M., May 1, 1895*)	Oct. 5, 1898
	MacAllister, Dickinson. Pres., Callister Mfg. Co, Box 635, Harrisburg, Pa	April 1, 1896
	MacCalla, Clifford Sherron. Gen. Mgr., The Washington Water Power Co., P. O. Drawer 2158 (Res., 2424 Second Ave.), Spokane, Wash	Mar. 1, 1910
	MacDiarmid, Milo Stuart. Asst. Engr., U. S. Lake Survey, 205 Old Custom House, Detroit, Mich. (*Assoc. M., Sept. 4, 1907*)	April 5, 1910
	MACDONALD, CHARLES. (*Past-President*). 115 Broadway, Room 1205, New York City	Sept. 15, 1869
	MacGregor, Robert Athole. Asst. Engr., Bureau of Highways, Borough of Manhattan, 13 Park Row (Res., 2428 Lorillard Pl.), New York City. (*Assoc. M., Nov. 2, 1898*)	Mar. 1, 1910
	Machen, Henry Bennett. Borough Engr., Dept., Water Supply, Gas and Electricity, 13 Park Row (Res., 315 West 97th St.), New York City. (*Jun., May 2, 1899; Assoc. M., Feb. 1, 1905*)	April 6, 1909
	MacKay, Henry Martyn. Prof. of Civ. Eng., McGill Univ., Montreal, Que., Canada	July 10, 1907
	Mackenzie, Alexander. Retired Chf. of Engrs. and Maj-Gen., U. S. A., The Birmingham, 2611 Adams Mill Rd., Washington, D. C. (*Hon. M., May 12, 1905*)	Feb. 2, 1887
	Mackintosh, Lachlan, City Engr., Mandalay, Burma, India	Jan. 31, 1911
	Macksey, Henry Vincent. 15 Court Sq., Boston, Mass	May 4, 1904
N.	Maclay, William Walter. Cons. Engr., Lee, Mass	Nov. 6, 1872

MEMBERS M

	Date of Membership
MacVicar, John Duncan. Asst. Engr., C., M. & P. S. Ry. (Res., 2317 Minor Ave., North), Seattle, Wash.	May 31, 1910
McCalla, William Augustus. City Engr., Decatur and New Decatur; Address, Decatur, Ala.	Nov. 30, 1909
McCann, Thomas Henry. Chf. Engr., Hoboken Mfrs. R. R. Co., Second National Bank Bldg., Hoboken, N. J.	April 2, 1890
McCarthy, George Arnold. Care, Smith, Kerry & Chace, Winch Bldg., Vancouver, B. C., Canada	Nov. 6, 1907
McCarty, Richard Justin. 3820 Warwick Boulevard, Kansas City, Mo.	Dec. 4, 1895
McCaustland, Elmer James. Prof. of Civ. Eng., Univ. of Washington; San. Engr., State Board of Health, 5264 Nineteenth Ave., N. E., Seattle, Wash. (*Assoc. M., Sept. 5, 1900*)	June 6, 1905
McClintock, J. Y. County Engr. of Monroe County, Rochester, N. Y.	Oct. 2, 1895
McClintock, William Edward. Chairman, Board of Control, 27 Crescent Ave., Chelsea, Mass.	Dec. 5, 1888
McClure, John Clarendon. Asst. Gen. Mgr., Ariz. East. R. R. and S. P. R. R. of Mexico, Tucson, Ariz. (*Assoc. M., Feb. 6, 1895*)	Jan. 3, 1911
McCollom, Thomas Chalmers. Civ. Engr., U. S. N. (*Retired*), 4606 Springfield Ave., Philadelphia, Pa.	May 3, 1882
McComb, Charles Oscar. Engr. and Contr., 403 University Bldg., Syracuse, N. Y.	May 2, 1900
McComb, David E. Hotel Bancroft, Washington, D. C.	Feb. 7, 1877
McConaghy, Robert Allen. Care, Chinese Eng. & Min. Co., Chinwangtao, North China	Feb. 1, 1910
McConnel, Wilfred Gillette. Chf. Engr., Rio de Janeiro Tramway, Light & Power Co., Ltd., Rio de Janeiro, Brazil	June 3, 1903
McCool, Daniel. Pres., Newaygo (Mich.) Portland Cement Co. and Grand Rapids Edison Co., Grand Rapids, Mich.	Sept. 5, 1883
McCormack, Edgar Walter. 2437 Eighteenth St., N. W., Washington, D. C. (*Assoc. M., March 6, 1901*)	Dec. 5, 1905
McCormick, George King. Roadmaster, L. & N. R. R., Etowah, Tenn. (*Jun., Feb. 6, 1889*)	May 4, 1898
McCormick, Ralph Steck. Chf. Engr., The Algoma Central Ry., Sault Ste. Marie, Ont., Canada	Oct. 3, 1911
McCormick, Robert Hugh. City Engr., Detroit, Mich.	Sept. 7, 1898
McCoy, Laurence Francis. Div. Engr., Canadian North. Ont. Ry., Nemegos, *via* Sudbury, Ont., Canada	Dec. 5, 1911
McCoy, Samuel Alexander. Contr. (Boynton, Church & McCoy), 1725 Eleventh Ave., Spokane, Wash. (*Assoc. M., Sept. 6, 1905*)	Dec. 4, 1906
McCrickett, Thomas Francis. Care, Russel Wheel & Foundry Co., Detroit, Mich.	Jan. 2, 1907
McCulloch, Robert Austen. Chf. Engr. with Raymond F. Almirall, Archt., 185 Madison Ave., New York City. (*Jun., Sept. 2, 1902; Assoc. M., Sept. 7, 1904*)	Sept. 3, 1907
McCulloh, Ernest. Project Engr., U. S. Reclamation Service, Sunnyside, Wash.	May 6, 1903
McCulloh, Walter. Cons. Engr., Niagara Falls, N. Y. (*Jun., July 4, 1888*)	June 7, 1893
McCullough, Ernest. Cons. Engr., 1302 Monadnock Blk., Chicago, Ill.	May 31, 1910
McDaniel, Allen Boyer. Prof. of Civ. Eng., Univ. of South Dakota; Cons. Engr. and Archt., Vermillion, S. Dak. (*Assoc. M., Nov. 1, 1905*).	Dec. 6, 1910
McDonald, Hunter. Chf. Engr., N., C. & St. L. Ry., 10 Terminal Station, Nashville, Tenn. (*Jun., April 4, 1883*)	Mar. 7, 1888
McDonald, John Alexander. Care, James E. McDonald 4 Chapel St., Cripplegate, London, E. C., England	Feb. 5, 1890
McDonald, William Naylor. Gen. Contr., 11 Baldwin Bldg., Jacksonville, Fla.	Sept. 3, 1902
McDonnell, Robert Emmett. Civ., Hydr. and San. Engr., Room 804, Scarritt Bldg., Kansas City, Mo.	Oct. 5, 1909
McDonough, Charles Joseph. Res. Engr., New York State Barge Canal, 42 Oxford Ave., Buffalo, N. Y.	Dec. 5, 1911
McDonough, James Albert. Junior Engr., U. S. Engr. Office, P. O. Box 75, Wheeling, W. Va. (*Assoc. M., April 3, 1907*)	May 3, 1910
McElroy, Fred Woodburn. With Bellew & Merritt Co., 226 Niagara St., Lockport, N. Y.	Sept. 6, 1910
McFarland, Walter Ashfield. Supt., Water Dept., Washington, D. C.	May 3, 1910
McFetridge, William Sutton. Plum St., Greenville, Pa. (*Jun., May 3, 1898; Assoc. M., Mar. 4, 1903*)	Sept. 3, 1907
McGilvray, Thomas Forrester. Cons. Engr.; City Engr., City Hall, Duluth, Minn. (*Assoc. M., Feb. 5, 1902*)	June 6, 1905
McGonigle, Charles Joseph. Contr. Mgr., Portland Office of Milliken Bros., Inc., 815 Chamber of Commerce Bldg., Portland, Ore. (*Assoc. M., May 6, 1908*)	Oct. 31, 1911
McGrew, Anson Burlingame. U. S. Asst. Engr., Room 2111, Farmers Bank Bldg., Pittsburgh, Pa.	June 4, 1902

	Date of Membership
McHenry, Edwin Harrison. Vice.-Pres., N. Y., N. H. & H. R. R., New Haven, Conn	Feb. 5, 1896
McInnes, Frank Alexander. Div. Engr., Sewer and Water Div., Public Works Dept., City Hall, Boston, Mass	Jan. 8, 1908
McKay, George Albert. Civ. Engr., U. S. N., Mare Island, Cal. (*Assoc. M., Feb. 4, 1903*)	Nov. 8, 1909
McKay, Hood. Pres., O. S. Richardson Coal Co., 203 South Dearborn St., Chicago, Ill	Nov. 6, 1907
McKeen, Benjamin. Gen. Mgr., Vandalia R. R., 806 Century Bldg., St. Louis, Mo	Nov. 6, 1895
McKenney, Charles Albert. Cons. Engr., Hibbs Bldg., Washington, D. C. (*Jun., Dec. 4, 1894; Assoc. M., Dec. 1, 1897*)	Mar. 2, 1909
McKenzie, Theodore Hall. Cons. Engr.; Engr. Member, State Board of Health, State Capitol, Hartford (Res., Southington), Conn	Sept. 7, 1881
McKibben, Frank Pape. Prof. of Civ. Eng., Lehigh Univ., South Bethlehem, Pa. (*Jun., Jan. 3, 1895; Assoc. M., Mar. 6, 1901*)	Oct. 3, 1905
McKim, Alexander Rice. Care, Conservation Comm., Albany, N. Y. (Res., 17 Gramercy Park, New York City). (*Assoc. M., April 4, 1894*)	May 4, 1898
McKim, James Arthur. Secy.-Treas., Westlake Const. Co., Mercantile Bldg., St. Louis, Mo	Oct. 2, 1901
McKinstry, Charles Hedges. Lt.-Col., Corps of Engrs., U. S. A., Federal Bldg., Cleveland, Ohio. (*Assoc. M., Sept. 2, 1896*)	May 3, 1899
McLain, Louis Randolph. Pres., Florida Eng. Co., St. Augustine, Fla	Feb. 2, 1881
McLean, Archibald. Asst. Engr., Dept. of Bridges, City of New York, 179 Washington St., Brooklyn, N. Y	May 6, 1903
McLoud, Paul. Div. Engr., State Highway Dept., Albany, N. Y	Sept. 6, 1910
McMath, Robert Emmet. Pres., R. E. McMath Surveying Co., 328 Lincoln Trust Bldg., St. Louis, Mo	Mar. 3, 1880
McMillan, Charles. Prof. of Civ. Eng., Princeton Univ.; Cons. Engr., Princeton, N. J	Jan. 29, 1868
McMillan, John Gilmore. County Surv., Santa Clara Co., Hall of Records, San José, Cal	Oct. 5, 1909
McMinn, Thomas James. (*Assistant Secretary*). 220 West 57th St., New York City (Res., 622 Ave. K, Flatbush, Brooklyn, N. Y.)	Mar. 5, 1890
McMorris, Daniel Webster. Prin. Asst. City Engr., Seattle, Wash	May 2, 1906
McMurtry, Guy. Yuba City, Cal	Mar. 2, 1909
McNab, William. Prin. Asst. Engr., G. T. Ry. System, Montreal, Que., Canada	Dec. 1, 1908
McNaugher, David White. (Robert W. Hunt & Co.), Monongahela Bank Bldg., Pittsburgh, Pa	June 3, 1908
McNeal, John. City Engr. and Supt. of Streets, Columbia, S. C	Dec. 2, 1903
McNicol, John Alexander. Box 733, Havana, Cuba	Sept. 1, 1897
McNulty, George Washington. 139 West 79th St., New York City	May 5, 1880
McPherson, Robert Henry. Engr., Robins Conveying Belt Co., 21 Park Row, New York City. (*Assoc. M., Jan. 4, 1905*)	June 6, 1911
McReynolds, Orval Omar. Cons. Civ. and Min. Engr., 20 Berges Bldg., Bakersfield, Cal. (*Assoc. M., Dec. 5, 1900*)	Mar. 5, 1907
Main, Charles Thomas. 201 Devonshire St., Boston, Mass	July 1, 1909
Mais, Henry Coathupe. 34 Murphy St., South Yarra, Melbourne, Victoria, Australia	June 6, 1883
Maitland, Alexander, Jr. 4104 Harrison St., Kansas City, Mo	Nov. 6, 1901
Malmros, Nils Lorentz. Care, Ernest Flagg, 109 Broad St., New York City	Feb. 1, 1910
Maloney, James Edward. Secy.-Engr., Colorado State Highway Comm., Littleton, Colo	Oct. 7, 1908
Maltby, Frank Bierce. 29 Broadway, New York City	April 3, 1895
Man, Albon Platt. Richmond Hill, N. Y	Sept. 5, 1883
Manahan, Elmer Gove. In Chg., Filtration Div., Dept. of Water Supply, Gas and Electricity, 13 Park Row, New York City. (*Assoc. M., Oct. 7, 1903*)	Feb. 2, 1909
Manchester, Ernest James Theodore. Pres., Metropolitan Water and Sewerage Board, Brisbane, Australia. (*Assoc. M., May 3, 1905*)	Oct. 4, 1910
Manley, Henry. Asst. Engr., Eng. Dept., Boston, 116 Mt. Vernon St., West Roxbury, Mass	June 2, 1880
Manley, Laurence Bradford. Asst. Engr., Boston Transit Comm., 15 Beacon St., Boston, Mass	July 1, 1909
Mann, John Laroy. Ingeniero del Gobierno, Dept. of Public Works, Santo Domingo, Santo Domingo. (*Jun., April 2, 1901; Assoc., May 6, 1902; Assoc. M., Sept. 1, 1908*)	Jan. 3, 1911
Manning, Rollo Glenroy. Engr., Ambridge Plant, Am. Bridge Co., Ambridge, Pa. (*Assoc. M., Oct. 2, 1901*)	Oct. 30, 1906
Manson, Marsden. City Engr., 2010 Gough St., San Francisco, Cal	Sept. 6, 1882
Marburg, Edgar. Prof. of Civ. Eng., Univ. of Pennsylvania, Philadelphia, Pa	Oct. 6, 1897
Marden, Walter Reuben. Vice-Pres. and Chf. Engr., The United Constr. Co., 467 Broadway, Albany, N. Y. (*Assoc. M., April 4, 1894*)	Feb. 28, 1905

	Date of Membership
Marple, William McKelvey. Chf. Engr., The Scranton Gas & Water Co., Dunmore Gas & Water Co., Olyphant Water Co., Archbald Water Co., and Consolidated Water Supply Co., Scranton, Pa.	June 4, 1890
Marr, William Walter. Cons. Civ. and San. Engr., 17 N. La Salle St., Chicago, Ill.	Feb. 2, 1909
Marroquin y Rivera, Manuel. 3ª Calle Manuel Mª Contreras No. 38, City of Mexico, D. F., Mexico	June 5, 1907
Marsh, Charles Fleming. Chf. Asst. Engr., Met. Water Board, Savoy Court, London, England	Oct. 3, 1906
Marsh, James Barney. Pres. and Chf. Engr., The Marsh Bridge Co., Des Moines, Iowa	May 3, 1905
Marshall, Horace Miller. U. S. Asst. Engr., Vicksburg, Miss.	Dec. 3, 1890
Marshall, Robert Albertsen. Structural Engr., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City	April 1, 1908
Marshall, Robert Bradford. Chf. Geographer, U. S. Geological Survey, Washington, D. C.	May 4, 1904
Marston, Anson. Dean of Div. of Eng., Iowa State Coll.; Cons. Engr., Ames, Iowa. (*Assoc. M., Oct. 4, 1893*)	Oct. 7, 1903
Marstrand, Otto Julius. 5 Lloyd's Ave., London, E. C., England	May 7, 1890
Martin, Edgar Darwin. 172 Washington St., Chicago, Ill.	July 1, 1909
Martin, James William. Supt. of Irrig., U. S. Indian Service, Toppenish, Wash. (*Assoc. M., Nov. 1, 1899*)	April 5, 1910
Martin, Kingsley Leverich. Vice-Pres., The Foundation Co., 115 Broadway, New York City. (*Jun., Nov. 5, 1895; Assoc. M., May 3, 1899*)	Dec. 1, 1903
Martin, William. 400 Dawson Ave., Bellevue, Pa.	Jan. 7, 1903
Martin, Wisner. Archt. and Engr., 141 Milk St., Boston, Mass. (*Jun., May 3, 1892; Assoc. M., July 3, 1895*)	May 1, 1901
Marvin, Frank Olin. Dean and Prof. of Civ. Eng., School of Eng., Univ. of Kansas, Lawrence, Kans.	May 5, 1897
MARX, CHARLES DAVID. (*Vice-President*). Prof. of Civ. Eng., Leland Stanford, Jr., Univ.; Cons. Engr., Stanford University, Santa Clara Co., Cal.	Oct. 7, 1896
Mason, Arthur John. (Hoover & Mason), Railway Exchange, Chicago, Ill.	Sept. 5, 1888
Mason, Francis. Engr. and Contr. (Mason, Hilton & Co.), 17 Battery Pl., New York City. (*Jun., April 3, 1900; Assoc. M., April 1, 1903*)	July 1, 1909
Mason, George Cotner. Engr. and Contr., Board of Trade Bldg., Portland, Ore. (*Jun., Mar. 6, 1894; Assoc. M., May 3, 1899*)	Sept. 1, 1908
Mason, Sampson Douglas. Asst. Engr., U. S. Fortification Work, Fort Worden, *via* Port Townsend, Wash.	Oct. 6, 1886
Mason, William Pitt. Prof. of Chemistry, Rensselaer Polytechnic Inst., and Water Specialist, Troy, N. Y.	Feb. 1, 1910
Matamoros, Luis. Gen. Director of Public Works of Costa Rica; Chf. Engr. of Constr., Costa Rica Pacific Ry., P. O. Box 295, San José, Costa Rica	Oct. 4, 1905
Mather, Thomas Hoggan. Chf. Engr., Rochester, Syracuse & Eastern Ry. and Allied Rys., Syracuse, N. Y.	Oct. 1, 1902
Mathewson, Isaac. Hacendado, Santa Fé, Guerrero, Mexico. (*Assoc. M., Mar. 7, 1894*)	Mar. 1, 1904
Mathewson, Thomas Knight. Chf. Engr., The Michoacán Power Co., Panindicuaro, Distrito de Puruándiro, Michoacán, Mexico	May 1, 1907
Matthes, Gerard Hendrik. Care, Pittsburgh Hydro-Electric Co., Connellsville, Pa. (*Assoc. M., June 6, 1900*)	Jan. 31, 1905
Maurice, Charles Stewart. Athens, Pa.	May 15, 1872
Maurice, George Holbrooke. Prin. Asst. Engr., Gulf, Florida & Alabama Ry., Room 713, Blount Bldg., Pensacola, Fla.	Jan. 4, 1910
Maury, Dabney Herndon. Cons. Engr., 129 North Jefferson Ave., Peoria, Ill.	May 3, 1899
Maxim, *Sir* Hiram Stevens. Ryecotes, Dulwich Common, London, S. E., England	Oct. 7, 1885
Maximoff, Sergius Pavlovitch. Engr. to the Imperial Russian Govt.; Asst. at the Imperial Inst. of Public Ways at St. Petersburg, Pet. St. 79, Bolchoi pz, St. Petersburg, Russia. (*Assoc. M., April 1, 1903*)	Sept. 1, 1908
Maxson, Frank Oscar. Civ. Engr., U. S. N., U. S. Naval Station, Box 337, Key West, Fla.	May 1, 1889
Maxwell, James Riddle. Cons. Engr., Newark, Del.	April 17, 1872
May, DeCourcy. Chairman, New York Shipbuilding Co., Camden, N. J.	Mar. 6, 1895
May, William Andrew. Gen. Mgr., Hillside Coal & Iron Co., Box 553, Scranton, Pa.	July 6, 1881
Mayer, Joseph. Prin. Asst. Engr., Quebec Bridge Comm., Canadian Express Bldg., Montreal, Que., Canada	Oct. 3, 1894
Mead, Charles Adriance. Engr. of Bridges, Board of Public Utility Commrs., State of New Jersey, Trenton (Res., 165 Wildwood Ave., Upper Montclair), N. J. (*Assoc. M., April 5, 1899*)	Jan. 5, 1904
Mead, Daniel Webster. Prof., Hydr. and San. Eng., Univ. of Wisconsin; Cons. Engr., 530 State St., Madison, Wis. (*Assoc. M., July 1, 1891*)	Dec. 6, 1893

	Date of Membership
Mead, Elwood. Chairman, State Rivers and Water Supply Comm.; Chf. Engr., Water Supply Dept., Melbourne, Victoria, Australia	June 7, 1893
Meads, Charles. Pres., Charles Meads & Co., 165 Broadway, New York City	Sept. 6, 1910
Means, Thomas Herbert. (Symmes & Means), 515 Mechanics Inst. Bldg., San Francisco, Cal. *(Assoc. M., July 10, 1907)*	Oct. 5, 1909
Mebus, Charles Fillmore. Civ. and San. Engr., 908 Land Title Bldg., Philadelphia, Pa.	May 2, 1906
Meem, James Cowan. Engr. for Frederick L. Cranford, 177 Montague St., Brooklyn, N. Y. *(Assoc. M., April 1, 1896)*	April 4, 1905
Meem, Stephen Halsey. Civ. and Min. Engr. (Meem & Haskins), Bluefield, W. Va.	Feb. 1, 1910
Mees, Curtis Adolph. Designing Engr., Southern Power Co., Charlotte, N. C. *(Assoc. M., Sept. 6, 1905)*	Nov. 2, 1908
Meigs, John. U. S. Asst. Engr., 812 Witherspoon Bldg., Philadelphia, Pa.	April 4, 1911
Meigs, Montgomery. U. S. Civ. Engr., U. S. Engr. Office, Keokuk, Iowa	Mar. 5, 1879
Melliss, David Ernest. Cons. Civ. and Min. Engr., 802 Fifth Ave., San Rafael, Cal.	Oct. 2, 1895
Melvin, David Nielson. Supt. and Engr., Am. Linoleum Mfg. Co., Linoleumville, N. Y.	July 3, 1878
Menden, William Stephen. Asst. Gen. Mgr., Brooklyn Rapid Transit Co., Brooklyn, N. Y.	April 4, 1906
Mendiola, Manuel Maria. Ingeniero de la Comision Hidrografica del Valle de Mexico, 1ª Calle Cordoba No. 3, City of Mexico, Mexico	Dec. 5, 1906
Mensch, Leopold Jehud. Gen. Contr., 138 North La Salle St., Chicago, Ill.	Oct. 4, 1905
Mercer, Charles Hatton. Chf. Engr., Bridge and Constr. Dept., The Pennsylvania Steel Co., Steelton, Pa. *(Assoc. M., Nov. 3, 1897)*	May 1, 1901
Meredith, Wynn. 907 Union Trust Bldg., San Francisco, Cal.	June 1, 1909
Merrill, George Nathan. Cons. Engr. (Merrill & Sears), 274 Main St., Springfield, Mass.	May 1, 1889
Merrill, William Fessenden. 830 Carlton Ave., Plainfield, N. J.	April 1, 1874
Merriman, Mansfield. 1071 Madison Ave., New York City. *(Jun., May 12, 1875)*	Sept. 3, 1884
Merriman, Thaddeus. Dept. Engr., Asst. to Chf. Engr., Board of Water Supply of the City of New York, 165 Broadway, New York City. *(Jun., April 4, 1899; Assoc. M., April 1, 1908)*	Dec. 6, 1910
Merritt, David Spencer. 104 Grove St., Tarrytown, N. Y.	Jan. 4, 1905
Merryman, William Curtis. Res. Engr., Rapid Transit Subway Constr. Co., 165 Broadway (Res., 537 West 149th St.), New York City	Oct. 4, 1899
Mersereau, Charles Vernon. 1324 Chemical Bldg., St. Louis, Mo.	Dec. 3, 1884
Mershon, Ralph Davenport. Cons. Engr., 60 Wall St. (Res., 65 West 54th St.), New York City	April 3, 1907
Meryweather, Henry Francis. Chf. Asst. Engr., Board of Public Works, 1276 Corona St., Denver, Colo.	April 1, 1908
Metcalf, Leonard. Cons. Engr. (Metcalf & Eddy), 14 Beacon St., Boston, Mass. *(Assoc. M., Jan. 5, 1898)*	Sept. 2, 1903
Meyer, Rudolf. Inspecting Engr., Water-Works and Sewerage System, Monterey, Mexico	Oct. 5, 1898
Middlebrook, Charles Trinder. Cons. Engr., 68 State St., Albany, N. Y.	Nov. 30, 1909
Miles, John Wiley. The American Club, City of Mexico, D. F., Mexico. *(Assoc. M., Oct. 2, 1901)*	April 6, 1909
Millard, Charles Sterling. Engr., Track and Roadway, C., C., C. & St. L. Ry., Cincinnati, Ohio. *(Jun., May 2, 1899; Assoc. M., June 5, 1901)*	Jan. 31, 1905
Miller, Charles Henry. Miller Eng. Co., Southern Trust Bldg., Little Rock, Ark.	May 2, 1899
Miller, Edward Furber. Prof. of Steam Eng., Mass. Inst. Tech., Boston (Res., 538 Ward St., Newton Center), Mass.	June 3, 1903
Miller, Frank. Cons. Engr. (Long & Miller), 220 Broadway, New York City	Oct. 5, 1904
Miller, Harvey Cooper. Contr. Engr., 1 Madison Ave., New York City	June 5, 1901
Miller, Hiram Allen. Cons. Engr., 8 Beacon St., Boston, Mass.	May 6, 1896
Miller, Rudolph Philip. Supt. of Bldgs., Borough of Manhattan, 220 Fourth Ave., New York City. *(Jun., Jan. 2, 1890; Assoc. M., April 7, 1897)*	Jan. 5, 1904
Miller, Samuel Osgood. Cons. Engr.; Asst. Prof. of Drawing, Columbia Univ., 117th St. and Broadway, New York City	June 30, 1911
Miller, Spencer. Chf. Engr., Cableway Dept., Lidgerwood Mfg. Co., 96 Liberty St., New York City. *(Assoc., July 3, 1889)*	Nov. 7, 1894
Millis, John. Col., Corps of Engrs., U. S. A., Federal Bldg., Cleveland, Ohio	Mar. 7, 1900
Mills, Arthur Lorenzo. Managing Director, Mexican Fuel & Power Co., Ltd., Apartado 123 Bis, City of Mexico, Mexico	May 2, 1888
Mills, Charles Malon. Cons. Engr., 4813 Beaumont Ave., West Philadelphia, Pa. *(Jun., June 2, 1886)*	Sept. 3, 1890

	Date of Membership
Miner, Charles Augustine. 530 Bond Bldg., Washington, D. C. (*Assoc. M., April 7, 1897*)	Dec. 4, 1901
Miner, Edward Fuller. Pres., Central Bldg. Co., Worcester, Mass	June 3, 1908
Minor, Edward Eastman. Supt., New Haven Water Co., 493 Edgewood Ave., New Haven, Conn. (*Jun., May 1, 1900*)	Mar. 4, 1908
Mitchell, Charles Hamilton. Cons. Engr. (C. H. & P. H. Mitchell), Traders Bank Bldg., Toronto, Ont., Canada. (*Assoc. M., June 4, 1902*).	Jan. 5, 1904
Mitchell, Samuel Phillips. Pres., Seaboard Constr. Co. and Am. Equipment Co., 1024 Witherspoon Bldg., Philadelphia, Pa	April 1, 1903
Mitchell, William Selby. U. S. Engr., Office, Custom House, St. Louis, Mo	June 1, 1909
Mixer, Charles Adam. Engr., Rumford Falls Power Co., Rumford, Me	Nov. 1, 1893
Moberly, Frank. Barrie, Ont., Canada	Oct. 7, 1903
Modjeski, Ralph. Cons. Engr., 1750 Monadnock Bldg., Chicago, Ill. (*Jun., Dec. 1, 1886; Assoc. M., July 1, 1891*)	Mar. 3, 1897
Mogensen, Olaf Einar. Engr., F. L. Smidth & Co., 50 Church St., Room 459, New York City. (*Assoc. M., April 7, 1897*)	Sept. 2, 1903
Mogensen, Peter. Civ. and Hydr. Engr., 1707 Eighth Ave., Spokane, Wash	July 10, 1907
Mohun, Edward. Union Club, Victoria, B. C., Canada	April 6, 1892
Moir, Ernest William. 10 Victoria St., Westminster, London, England	Sept. 7, 1904
Moisseiff, Leon Solomon. Engr. of Design, Dept. of Bridges, City of New York, Park Row Bldg., New York City. (*Jun., Dec. 3, 1895; Assoc. M., Sept. 5, 1900*)	Dec. 3, 1907
Molera, Eusebius Joseph. 2025 Sacramento St., San Francisco, Cal	Oct. 5, 1904
Molitor, David Albert. Civ. and Cons. Engr., 205 Old Custom House, Detroit, Mich	Oct. 6, 1897
Molitor, Frederic. Cons. Engr., 35 Nassau St., New York City	Nov. 4, 1896
Moncrieff, Alexander Bain. Railways Commr., Adelaide, South Australia.	July 4, 1894
Moncrieff, John Mitchell. Pearl Bldgs., Newcastle-upon-Tyne, England.	Nov. 3, 1897
Moncure, William Augustus. Engr. of R. of W., P. R. R., Broad St. Station, Philadelphia, Pa. (*Jun., June 21, 1894; Assoc. M., Oct. 7, 1896*)	June 5, 1906
Monroe, Richard. U. S. Asst. Engr., U. S. Engr.'s Office, Rock Island, Ill.	June 1, 1909
Monroe, Will Klahr. Mgr., Eng. Dept., The Brown Hoisting Machinery Co., Cleveland, Ohio	Oct. 7, 1908
Montfort, Richard. Cons. Engr., L. & N. R. R., Louisville, Ky	June 6, 1888
Moody, Burdett. Cons. Min. Engr., 1043 San Pasqual St., Pasadena, Cal. (*Assoc. M., Feb. 3, 1897*)	June 5, 1901
Moore, Charles Edward. Cons. Engr., Santa Clara, Cal	Jan. 7, 1880
Moore, Charles Gillingham. 12 Scott St., Buffalo, N. Y. (*Assoc. M., Mar. 5, 1902*)	June 1, 1909
Moore, Charles Harry. Prin. Asst. Engr., Erie R. R., N. Y., S. & W. R. R., N. J. & N. Y. R. R., and Chi. & Erie R. R., 50 Church St., New York City. (*Assoc M., April 5, 1893*)	Sept. 4, 1901
Moore, Egbert Jessup. Chf. Engr., Turner Constr. Co., 11 Broadway, New York City (Res., 80 Cornell Ave., Yonkers, N. Y.). (*Jun., Mar. 31, 1903; Assoc. M., Feb. 7, 1906*)	May 31, 1910
Moore, Fred Forrest. Designing Engr., Board of Water Supply, 165 Broadway, New York City	April 3, 1907
Moore, James Edwin Alexander. Chf. Engr., C. O. Bartlett & Snow Co., Cleveland, Ohio	June 5, 1901
Moore, John Edwin. Chemist for Robert W. Hunt & Co., 1121 The Rookery, Chicago, Ill	Oct. 5, 1904
Moore, John William. Cons. Engr., 3342 North Illinois St., Indianapolis, Ind	Feb. 2, 1909
MOORE, ROBERT. (*Past-President*). Cons. Engr., Merchants-Laclede Bldg., St. Louis, Mo	April 5, 1876
Moore, William Edwin. Cons. Engr., 220 Paulsen Bldg., Spokane, Wash.	Feb. 7, 1906
Moore, William Harley. Engr. of Bridges, N. Y., N. H. & H. R. R., New Haven, Conn	June 4, 1895
Moore, William Smelsor. City Engr., City Hall, South Bend, Ind	Sept. 5, 1911
Moorshead, Thomas Courtney. Chf. Engr., Ill. Terminal R. R.; Supt. of Constr., Illinois Glass Co., Alton, Ill. (*Assoc. M., Mar. 1, 1905*)	June 30, 1910
Moran, Daniel Edward. Cons. Engr., 55 Liberty St., New York City. (*Assoc. M., June 3, 1891*)	Jan. 1, 1896
Mordecai, Augustus. Cons. and Const. Engr., 1328 Citizens Bldg., Cleveland, Ohio	Feb. 1, 1893
Moritz, Charles Holland. Gen. Supt., Aluminum Co. of America, Niagara Falls, N. Y. (*Assoc. M., Oct. 2, 1901*)	April 2, 1907
Morley, Fred. Lapeer, Mich. (*Assoc. M., May 6, 1891*)	Mar. 4, 1896
Morrill, Asa Hall. 44 Tremlett St., Dorchester, Mass	May 3, 1910
Morrill, George Pillsbury. Ingeniero Primero de Obras Publicas, Sagua la Grande, Cuba. (*Assoc. M., Jan. 2, 1907*)	June 6, 1911
Morrill, George Sullivan. 44 Tremlett St., Dorchester, Mass	Mar. 2, 1887

	Date of Membership
Morris, Charles John Augustus. Cons. Engr. and Contr., P. O. Box 254, St. Paul, Minn.	Oct. 3, 1883
Morris, Clyde Tucker. Prof. of Structural Eng., Ohio State Univ., Columbus, Ohio. (*Assoc. M., Mar. 6, 1907*)	Nov. 8, 1909
Morris, Henry Gurney. Engr. and Machinist, Commonwealth Trust Bldg., Philadelphia, Pa.	Dec. 4, 1867
Morris, Lardner Vanuxem. Chf. Engr., Bay Ridge Impvt., L. I. R. R., 1964 Broadway, Brooklyn, N. Y.	May 3, 1905
Morris, Marshall. Cons. Engr., 303 Norton Bldg., Louisville, Ky.	Mar. 5, 1873
Morris, Marshall, Jr. 2914 San Jacinto St., Houston, Tex.	Feb. 1, 1910
Morris, William Cullen. Engr. of Constr., Consolidated Gas Co. of New York and The Astoria Light, Heat & Power Co., 124 East 15th St., New York City	Oct. 7, 1908
Morrison, Harry Johnson. 201 Fremont St., Peekskill, N. Y. (*Assoc. M., Jan. 4, 1899*)	April 4, 1905
Morrison, Henry Prentice. Broadway and Forest Ave., West New Brighton, N. Y.	April 6, 1898
Morrison, Thomas John. Gen. Contr. (Leary & Morrison Co.), Fairport, N. Y.	April 6, 1909
Morrow, Jay Johnson. Maj., Corps of Engrs., U. S. A., 802 Couch Bldg., Portland, Ore. (*Assoc. M., June 5, 1901*)	Mar. 1, 1904
Morse, Benjamin Franklin. 2187 E. 71st St., S. E., Cleveland, Ohio	July 12, 1877
Morse, Charles Adelbert. Chf. Engr., "Santa Fé" System, 1021 Van Buren St., Topeka, Kans.	April 6, 1898
Morse, Charles James. 1825 Asbury Ave., Evanston, Ill.	Feb. 6, 1884
Morse, Charles Miller. 5 Beekman St., New York City (Res., Buffalo, N. Y.)	Jan. 2, 1895
Morse, Edwin Kirtland. 1801 Commonwealth Bldg., Pittsburgh, Pa.	June 6, 1900
Morse, George Frederick. 601 Ave. E, Bayonne, N. J.	April 3, 1907
Morse, Walter Levi. Terminal Engr., N. Y. C. & H. R. R. R., Room 5621, Grand Central Station, New York City	May 3, 1910
Morse, William Prentiss. Asst. City Engr. of Newton, City Hall, West Newton, Mass.	May 4, 1909
Morton, Walter Scott. 2 Rector St., New York City	Oct. 3, 1906
Moses, John Cranch. Engr. of Constr., The Boston Bridge Works, Inc., Cambridge, Mass. (*Jun., July 2, 1890; Assoc. M., May 4, 1898*)	May 3, 1904
Mosman, Alonzo Tyler. Asst., U. S. Coast and Geodetic Survey, Coast Survey Office, Washington, D. C.	July 1, 1885
Mosscrop, Alfred Mitton. Director, Dorman, Long & Co., Ltd., Middlesbrough, England; Res., 36 East Boulevard, Rochester, N. Y. (*Jun., May 4, 1887; Assoc. M., May 3, 1893*)	Oct. 4, 1899
Moulton, Guy. First Res. Engr., Middle Div., New York State Canals, Canal Office, Syracuse, N. Y.	Mar. 1, 1905
Mowlds, Eugene. Engr., Edge Moor Plant, Am. Bridge Co., Edge Moor, Del.	Oct. 2, 1907
Mozart, William Jacob. Cons. and Const. Engr., Flanders Rd., Westborough, Mass. (*Assoc. M., April 3, 1907*)	Jan. 31, 1911
Muckleston, Hugh Burritt. Care, J. S. Dennis, Calgary, Alta., Canada	Jan. 2, 1912
Muenscher, Emory Washburn. County Engr., Manistee, Mich.	July 5, 1893
Mueser, William. (Concrete-Steel Eng. Co.), Park Row Bldg., New York City	Feb. 7, 1906
Muhs, Frederick Ross. Crocker Bldg., San Francisco, Cal.	Oct. 7, 1908
Muirhead, James Herbert Hawksworth. Cons. Engr., Compania de los Puertos de Cuba, Calle Marina Alta No. 5, Santiago de Cuba, Cuba	Oct. 3, 1911
Mulholland, William. 422 South Hill St., Los Angeles, Cal.	Feb. 6, 1907
Müller, Ejnar Jönsberg. Cons. Engr., 17 Museum Rd., Shanghai, China.	Jan. 8, 1908
Münster, Andrew Wendelbo. Cons. Engr., 444 Central Bldg., Seattle, Wash.	May 1, 1889
Muralt, Carl Leonard de. Prof. of Elec. Eng., Univ. of Michigan; Cons. Engr., New Eng. Bldg., Ann Arbor, Mich.	Aug. 31, 1909
Murphy, Daniel William. Engr. in Chg. of Washington Office Eng., U. S. Reclamation Service, Washington, D. C.	Feb. 2, 1909
Murphy, Edward Charles. Dist. Engr., Water Utilization Branch, U. S. Geological Survey, Napa, Cal. (*Assoc. M., Sept. 5, 1900*)	Mar. 31, 1908
Murphy, James Cornelius. (D. X. Murphy & Bro.), 140 South 5th St., Louisville, Ky.	June 6, 1911
Murray, John Francis. Asst. to Chf. Engr., P. R. R., Broad St. Station, Philadelphia, Pa.	Mar. 7, 1906
Murtaugh, Mark Maurice. Cons. Hydr. and Constr. Engr., Alta Club, Salt Lake City, Utah	May 1, 1907
Musson, Eugene Francis. Norwich, N. Y.	May 2, 1906
Myers, Charles Hayward. 45 Broadway, New York City	Aug. 5, 1868
Myers, Edmund Trowbridge Dana, Jr. Pres., Richmond Iron Works, Richmond, Va. (*Jun., May 2, 1888*)	June 7, 1899

	Date of Membership
NAGLE, JAMES C. Dean and Prof. of Civ. Eng., School of Eng., Agri. and Mech. Coll. of Texas, College Station, Tex. (*Assoc. M., April 5, 1899*)	June 6, 1905
NAUMAN, GEORGE. Asst. Engr., Constr., P. R. R., 406 First National Bank Bldg., Sunbury, Pa	May 4, 1904
NAYLOR, EZRA BOOTH. 436 Park Hill Ave., Yonkers, N. Y	Sept. 5, 1911
NEALE, JOHN COLWELL. Structural Engr., Carnegie Steel Co., Carnegie Bldg., Pittsburgh, Pa	Jan. 7, 1903
NEELD, CHARLES MARSHALL. Pres., C. M. Neeld Constr. Co., Oliver Bldg., Pittsburgh, Pa	Oct. 7, 1908
NEELY, WILLIAM RIDLEY. Asst. Engr. in Chg. of Section, Board of Water Supply of New York City, New Paltz, N. Y	July 9, 1906
NEHER, CLARENCE RUFUS. Box 724, Whitehall, N. Y	June 4, 1902
NEHER, FRANK. Asst. Engr., Mo. Pac. Ry., St. Louis, Mo	Oct. 4, 1905
NEILSON, GEORGE HARRISON. Gen. Mgr., Braeburn Steel Co., Braeburn, Pa.	Oct. 5, 1904
NELSON, ARCHY MAGILL. Asst. Engr., Ore. Short Line R. R. and S. P. Co., Room 518, Vermont Bldg., Salt Lake City, Utah	Oct. 4, 1910
NELSON, GEORGE ALFRED. Asst. Engr., City Engr.'s Office, Lowell, Mass.	April 4, 1911
NELSON, JAMES AUGUSTUS. Gen. Mgr., The East Jersey Pipe Co., Paterson, N. J	Mar. 2, 1909
NETHERCUT, EDGAR S. (Parmley & Nethercut), 1517 Monadnock Blk., Chicago, Ill	April 6, 1904
NEWBROUGH, WILLIAM. Civ. and Min. Engr., Evanston, Wyo	April 6, 1904
NEWELL, FREDERICK HAYNES. Director, U. S. Reclamation Service, Washington, D. C	Dec. 5, 1900
NEWELL, JOSEPH PETTUS. 911 Spalding Bldg., Portland, Ore	Oct. 2, 1907
NEWMAN, EMIL. Asst. Engr., Pacific Light & Power Co., 1048 West 8th St., Los Angeles, Cal	Jan. 4, 1905
NEWMAN, ROBERT MORRIS. Jackson, Mich	May 6, 1874
NEWTON, ALBERT WILLIAM. Gen. Insp., Permanent Way and Structures, C., B. & Q. R. R., Chicago, Ill	Dec. 6, 1905
NEWTON, RALPH EELLS. Pres., Newton Eng. Co., 434 Jackson St., Milwaukee, Wis. (*Assoc. M., Jan. 8, 1902*)	Feb. 2, 1909
NICHOL, JOHN. Western Springs, Cook Co., Ill. (*Assoc., Oct. 2, 1872*)	April 5, 1876
NICHOLS, CHARLES HART. Cons. Engr., 1133 Broadway, New York City	Nov. 8, 1909
NICHOLS, CHARLES HENRY. Cons. Engr.; Engr., Conn. Shell Fish Comm., New Haven, Conn. (*Jun., May 2, 1893; Assoc. M., May 2, 1900*)	Feb. 28, 1905
NICHOLS, EDWIN JAY. Res. Engr., Stephenville North & South Ry., Stephenville, Tex	Sept. 2, 1896
NICHOLS, LEWIS ABEL. Cons. Engr.; Pres., Chicago Steel Tape Co., 6231 Cottage Grove Ave., Chicago, Ill	Oct. 5, 1892
NICHOLS, WILLARD ATHERTON. Redlands, Cal	May 7, 1873
NICHOLSON, FRANK LEE. Chf. Engr., Norfolk Southern R. R., 218 Graydon Park, Norfolk, Va	Dec. 6, 1905
NICHOLSON, MAURY. City Engr., City Hall, Birmingham, Ala	Jan. 2, 1912
NICOLLS, WILLIAM JASPER. Cons. Engr., 320 Pennsylvania Bldg., Philadelphia, Pa	June 5, 1878
NICOLSON, GEORGE LLEWELLYN. Gen. Mgr., C. & O. Canal, Washington, D. C	Dec. 5, 1894
NOBLE, ALFRED. (***Past-President***). 7 East 42d St., New York City. (***Jun., Sept. 2, 1874***)	April 3, 1878
NOBLE, FREDERICK CHARLES. Div. Engr., Public Service Comm. for the First Dist., 23 Flatbush Ave., Brooklyn, N. Y. (*Assoc. M., June 4, 1902*)	Mar. 1, 1910
NOBLE, THERON AUGUSTUS. Cons. Engr., 207 Miller Bldg., North Yakima, Wash	June 2, 1897
NORBOE, PAUL MANINGHAM. Asst. State Engr., 3730 Magnolia Ave., Sacramento, Cal	Nov. 1, 1905
NORCROSS, JOSEPH ARNOLD. Secy. and Treas., The New Haven Gas Light Co., 80 Crown St., New Haven, Conn	April 5, 1905
NORCROSS, ORLANDO WHITNEY. Pres., The Norcross Bros. Co., Worcester, Mass	Oct. 31, 1911
NORRIS, ROBERT VAN ARSDALE. Cons. Engr., 524 Second National Bank Bldg., Wilkes-Barre, Pa. (*Jun., Dec. 7, 1887*)	Mar. 5, 1902
NORTON, ALBERT GRAY. Const. Engr. and Archt., Middletown, N. Y	Dec. 4, 1901
NORTON, HOMER BURDETT. Chf. Engr., Elk Tanning Co., Ridgway, Pa	June 3, 1908
NOSKA, GEORGE ALBERT. Summit Driveway, River View Manor, Hastings-on-Hudson, N. Y. (*Jun., Mar. 31, 1896; Assoc. M., Sept. 3, 1902*)	Sept. 5, 1911
NOSTRAND, PETER ELBERT. Cons. Engr. and City Surv., 7 Beekman St., New York City. (*Assoc. M., Sept. 7, 1892*)	Mar. 6, 1895
NOYES, ELLIS BRADFORD. Civ. Engr.'s Office, U. S. Navy Yard, Norfolk, Va. (*Jun., July 7, 1880*)	Oct. 2, 1889
NUEBLING, EMIL LOUIS. Supt. and Engr., Dept. of Water, Reading, Pa.	Dec. 7, 1904
NUGENT, PAUL COOK. Prof. of Civ. Eng., Syracuse Univ., 417 University Pl., Syracuse, N. Y	May 3, 1910
NUNN, PAUL N. Chf. Engr., Telluride Power Co., Provo, Utah	Sept. 7, 1904
NYEBOE, MARIUS IB. Esperance Alle 12, Charlottenlund, Denmark	July 9, 1906

	Date of Membership
Oakes, John Calvin. Maj., Corps of Engrs., U. S. A., Custom House, Cincinnati, Ohio. (*Assoc. M., May 1, 1907*)	May 31, 1910
Oakley, Frank Thompson. Bridge Engr., Northwestern Pacific R. R., San Francisco; Address, 2 Mesa Ave., Oakland, Cal. (*Assoc. M., Feb. 6, 1895*)	June 6, 1900
Ober, Ralph Hadlock. Supt. of Bldgs., City of Seattle, Room 222, Municipal Bldg., Seattle, Wash	Dec. 4, 1907
O'Brien, Arthur. Cons. Engr., 1127 Sunset Ave., Utica, N. Y	July 1, 1909
O'Brien, Joseph Henry. With Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City. (*Assoc. M., May 1, 1901*)	Sept. 5, 1905
OCKERSON, JOHN AUGUSTUS. (*President*). Cons. Engr.; Member, Mississippi River Comm., 1301 Liggett Bldg., St. Louis, Mo	July 7, 1880
Odell, Frederick Sylvester. Port Chester, N. Y	Mar. 5, 1884
O'Donnell, John Patrick. Palace Chambers, Westminster, London, S. W., England	July 5, 1893
Oestreich, Henry Lewis. Senior Asst. Div. Engr., Public Service Comm., 565 Fifth Ave. (Res., 429 Sixteenth St.), Brooklyn, N. Y. (*Jun., Oct. 4, 1892; Assoc. M., Dec. 6, 1899*)	April 6, 1909
Ogawa, Umesaburo. Prof. of Civ. Eng., Kyoto Imperial Univ., Kyoto, Japan	Dec. 4, 1907
Ogden, Henry Neely. Special Asst. Engr., State Dept. of Health, and Prof. of San. Eng., Cornell Univ., Ithaca, N. Y. (*Jun., Oct. 3, 1893; Assoc. M., Oct. 5, 1898*)	Nov. 30, 1909
Ogden, James Clarence. Mgr., New York Office, Robert W. Hunt & Co., 90 West St., New York City	Oct. 3, 1911
O'Hanly, John Lawrence Power. Cons. Engr., 112 Lisgar St., Ottawa, Ont., Canada	Sept. 5, 1883
Okeson, Walter Raleigh. Res. Engr., The Phœnix Bridge Co., 49 William St., New York City	June 6, 1911
Olcott, Eben Erskine. Min. Engr., 36 Wall St., New York City	July 5, 1893
Oliver, Emery. Care, Hammon Eng. Co., Forum Bldg., Sacramento, Cal.	Mar. 7, 1906
Olmsted, Ashbel Edward. Div. Engr., Rap. Trans. Subway Constr. Co., 165 Broadway, New York City	May 6, 1903
Olmsted, Frank Henry. (Olmsted & Gillelen), 604 Wright and Callender Bldg., Los Angeles, Cal	Feb. 7, 1900
Olney, Alfred Clarence. 2816 Fairview Ave., Birmingham, Ala. (*Jun., April 30, 1895*)	Nov. 2, 1898
Olney, LaFayette. Cons. Engr., Sea Cliff, N. Y	Oct. 7, 1868
Opdyke, Stacy Brown, Jr. Contr. Engr., 1931 Broadway, New York City.	Feb. 2, 1876
Orange, James. 3 Gray's Inn Sq., London, England	Dec. 3, 1890
Ornellas, Charles Evariste d'. 4002 Carrientes, Buenos Aires, Argentine Republic	Oct. 3, 1911
O'Rourke, John Francis. Pres., O'Rourke Eng. Constr. Co.; Cons. Engr., 345 Fifth Ave., New York City	April 2, 1884
Orr, David Kirk. Engr., The Monongahela R. R., Brownsville, Pa	April 4, 1911
Orr, John. Prof. of Eng., South African School of Mines and Technology, Box 1176, Johannesburg, South Africa	Oct. 4, 1910
Orrok, George Alexander. Mech. Engr., New York Edison Co., 55 Duane St., New York City	June 6, 1906
Osborn, Frank Chittenden. Cons. Engr., Osborn Bldg., Cleveland, Ohio.	Oct. 3, 1888
Osgood, Joseph Otis. Chf. Engr., C. R. R. of N. J., 143 Liberty St., New York City. (*Jun., May 3, 1876*)	Mar. 5, 1879
O'Shaughnessy, Michael Maurice. Chf. Engr., Southern California Mountain Water Co.; Cons. Engr., 14 Montgomery St., San Francisco, Cal.	June 4, 1902
Ostrander, John Edwin. Prof. Math. and Civ. Eng., Mass. Agri. Coll., Amherst, Mass. (*Jun., May 2, 1888; Assoc. M., Sept. 2, 1891*)	April 4, 1905
Ostrom, John Nelson. Bridge Engr., 1626 Farmers Bank Bldg., Pittsburgh, Pa	Nov. 5, 1890
Ostrup, John Christian. Cons. Engr., 17 Battery Pl., New York City. (*Assoc. M., Mar. 4, 1896*)	Mar. 1, 1899
Otagawa, Masayuki. Ashio Copper Mines, Shimotsuke, Japan	Jan. 2, 1895
Otis, George Ellison. Cons. Engr., Mansfield, Ark	July 3, 1895
Owen, James. Cons. Engr., 196 Market St., Newark, N. J	Sept. 15, 1869
Owens, Henry Kinder. Chf. Engr., Hanford Irrig. & Power Co., 702 Hoge Bldg., Seattle, Wash	Mar. 6, 1889
Oxholm, Theodor Smidt. Engr. in Chg., Bureau of Eng.-Constr., Office, Pres. of the Borough of Richmond, Borough Hall, New Brighton, N. Y.	Nov. 3, 1897

Packard, Ralph Gooding. Pres. of the R. G. Packard Co., 130 Pearl St., New York City	Feb. 17, 1869
Page, Logan Waller. Director, Office of Public Roads, U. S. Dept. of Agriculture, 2223 Massachusetts Ave., Washington, D. C	July 1, 1909
Page, William Nelson. 1863 Kalorama Rd., N. W., Washington D. C.	May 3, 1905
Paget, Edmund Winter. Apartment No. 405, The Barker, N. W. Cor., 21st and Irving Sts., Portland, Ore	June 5, 1901

MEMBERS P

	Date of Membership
Palmer, Frederick. Chf. Engr., Port of London Authority, 109 Leadenhall St., London, E. C., England	Oct. 4, 1899
Palmer, John Elden. 32 Lindsey St., Dorchester, Mass	June 1, 1904
Palmer, John Geary. Asst. Engr., New York State Barge Canal, Montezuma, N. Y	Oct. 7, 1908
Palmer, Shepard Brown. (Chandler & Palmer), 161 Main St., Norwich, Conn	April 4, 1911
Pardee, James Thomas. Cons. Engr., 10220 Clifton Boulevard, N. W., Cleveland, Ohio. (*Assoc. M., June 5, 1895*)	June 5, 1901
Paret, Milnor Peck. Montrose, Colo	Sept. 2, 1885
Parker, Adelbert Franklin. 585 Twenty-eighth St., Ogden, Utah	Aug. 31, 1909
Parker, Charles Jeremiah. Prin. Asst. Engr., N. Y. C. & H. R. R. R., Grand Central Terminal, New York City	Feb. 7, 1900
Parker, Frederick Yancy. U. S. Engr. Office, Custom House, St. Louis, Mo	June 1, 1909
Parker, Harold. (Parker, Bateman & Chase); Member, Wachusett Mt. State Reservation Comm.; First Vice-Pres., Hassam Paving Co., 390 Main St., Worcester (Res., So. Lancaster), Mass	June 7, 1899
Parker, Maurice Stiles. St. Maries, Idaho	Feb. 5, 1890
Parker, Orlando Kenton. Cons. Engr., Box 3, R. F. D. No. 3, Los Angeles, Cal	June 6, 1906
Parker, William Pool. Chf. Engr., A. M. Blodgett Constr. Co., 411 Security Bldg., Galveston, Tex. (*Assoc. M., Oct. 5, 1904*)	Sept. 1, 1908
Parks, Charles Wellman. Civ. Engr., U. S. N.; Inspecting Engr., Gen. Elec. Works, Schenectady, N. Y	Oct. 3, 1906
Parks, Oren Elisha. Gen. Mgr., Woronoco Constr. Co., Div. 2, Gillett Blk., Westfield, Mass	Dec. 6, 1905
Parmley, Walter Camp. (Parmley & Nethercut), 45 East 17th St., New York City. (*Assoc. M., April 1, 1896*)	June 1, 1898
Parsons, Burt Hewitt. Mech. Engr of The Mississippi River Power Co., Keokuk, Iowa	Feb. 6, 1907
Parsons, Harold Ashton. 1 Bank St., Stamford, Conn. (*Assoc. M., May 1, 1907*)	Dec. 6, 1910
Parsons, Harry de Berkeley. Prof. Emeritus, Rensselaer Polytechnic Inst.; Cons. Engr., 22 William St., New York City	Feb. 3, 1897
Parsons, Henry Cuyler. Tweddle Bldg., Albany, N. Y	Oct. 6, 1886
Parsons, Robert Stevens. Supt., E. R. R., Jersey City, N. J	Sept. 6, 1905
Parsons, William Barclay. Cons. Engr., 60 Wall St., New York City. (*Jun., June 7, 1882*)	Nov. 2, 1887
Paschke, Theodore. 1 West 100th St., New York City	Mar. 7, 1894
Patch, Walter Woodbury. Project Engr., U. S. Reclamation Service, Klamath Falls, Ore. (*Assoc. M., Sept. 7, 1904*)	Jan. 7, 1908
Paterson, Harry Thomas. U. S. Asst. Engr., Newbern, N. C. (*Assoc. M., Feb. 3, 1904*)	May 4, 1909
Patrick, Mason Mathews. Lt.-Col., Corps of Engrs., U. S. A., Custom House, Norfolk, Va	Oct. 7, 1903
Patten, Henry Benjamin. 314 East 18th St., Cheyenne, Wyo	Jan. 4, 1888
Patten, William Nickels. Asst. Constr. Mgr., Stone & Webster Eng. Corporation, 147 Milk St., Boston, Mass	June 30, 1910
Patterson, John Curtis. 300 Franklin Bank Bldg., Philadelphia, Pa	Oct. 2, 1889
Patterson, William Rodney. 1448 Monadnock Blk., Chicago, Ill	May 4, 1909
Patton, William Baird. Mgr., The Duluth Eng. Co., 612 Palladio Bldg., Duluth, Minn	May 2, 1911
Paul, Charles Howard. Constr. Engr., Arrowrock Dam, U. S. Reclamation Service, Boise, Idaho. (*Assoc. M., June 7, 1905*)	Sept. 1, 1908
Payne, Edwin Van Rensselaer. Barge Canal Res. Engr., Fort Edward, N. Y	May 6, 1908
Payne, William Arthur. Gen. Supt. of Constr. and Engr. with Charles T. Wills, Inc., 286 Fifth Ave., New York City	Feb. 1, 1910
Peabody, William Welcome. Div. Engr., Board of Water Supply, New York City, White Plains, N. Y	April 6, 1909
Pearl, James Warren. Asst. Engr., Chicago Subway Comm., 6050 Stoney Island Ave., Chicago, Ill	Jan. 2, 1889
Pearl, Walter. Cons. Engr., 407 South Alamansor St., Alhambra, Cal	June 3, 1908
Pearson, Edward Jones. First Vice-Pres., Mo. Pac. Ry., 703 Missouri Pacific Bldg., St. Louis, Mo	Dec. 4, 1907
Pearson, Fred Stark. Cons. Engr., 25 Broad St., New York City	Nov. 3, 1897
Peary, Robert Edwin. Rear-Admiral, U. S. N. (*Retired*), South Harpswell, Me	Mar. 3, 1886
Peck, John Gates. Chf. Engr. and Shop Mgr. for J. B. & J. M. Cornell Co., Cold Spring, N. Y. (*Assoc. M., Sept. 3, 1902*)	Nov. 1, 1910
Pegram, George Herndon. Chf. Engr., Interborough Rap. Trans. Co. and Rap. Trans. Subway Constr. Co., 165 Broadway, New York City. (*Jun., April 7, 1880*)	Jan. 3, 1883
Peimbert, Angel. Res. Engr., S. Pearson & Son, Inc., 2ª Puente de Alvarado No. 33, City of Mexico, Mexico	July 9, 1906

	Date of Membership
Pelz, Carl Edouard. Engr., Public Service Comm., Second Dist., Metropolitan Tower, New York City	May 2, 1911
Pemoff, Joel Juk. Asst. Engr., Dept. of Docks and Ferries in Chg. of the Chelsea Section, Pier A, North River, New York City. (*Assoc. M., Nov. 5, 1902*)	Nov. 2, 1908
Pence, William David. Prof. of Railway Eng., Univ. of Wisconsin; Engr., Wisconsin State Board of Assessment and Railroad Comm. of Wisconsin, Madison, Wis	Oct. 4, 1899
Pendergrass, Robert Allen. Chf. Draftsman, Rankin Plant, McClintic-Marshall Constr. Co., 105 Savannah Ave., Wilkinsburg, Pa. (*Assoc. M., June 3, 1908*)	Oct. 31, 1911
Penfield, William Henry. Asst. Chf. Engr., C., M. & St. P. Ry., Room 1359, Ry. Exchange Bldg., Chicago, Ill	Mar. 1, 1905
Perkins, Albert Henry. Div. Engr., Conservation Comm. of New York State, Albany, N. Y. (*Assoc. M., Feb. 7, 1906*)	April 4, 1911
Perkins, Charles Ezra. Akron, Ohio	June 6, 1906
Perkins, Charles Penrose. 2005 De Lancey St., Philadelphia, Pa. (*Jun., Feb. 3, 1875*)	April 5, 1882
Perkins, Edmund Taylor. Pres. and Chf. Engr., Edmund T. Perkins Eng. Co., 1110 First National Bank Bldg., Chicago, Ill	Dec. 3, 1902
Perrilliat, Arsène. Cons. and Contr. Engr., 1007 Hibernia Bank Bldg., New Orleans, La. (*Assoc. M., June 7, 1893*)	April 5, 1899
Perrine, George. 820 West End Ave., New York City	April 6, 1909
Perrine, Ren Brown. (Prack & Perrine), 1410 Keystone Bldg., Pittsburgh, Pa	May 31, 1910
Perry, Chauncy Rusch. Greenwood Ave., Waltham, Mass. (*Assoc. M., Feb. 1, 1905*)	June 1, 1909
Peterson, Peter Alexander. Mount Royal Club, Montreal, Que., Canada.	Jan. 5, 1876
Pettee, Eugene Everett. Cons. Engr. (J. R. Worcester & Co.), 79 Milk St., Boston, Mass. (*Assoc. M., Sept. 3, 1902*)	Mar. 2, 1909
Pettigrew, Thomas. 1170 Broadway, New York City	Oct. 4, 1893
Pew, Arthur. Cons. Engr., 619 Temple Court Bldg., Atlanta, Ga	Dec. 2, 1885
Peyton, John Howe. Asst. to Pres., L. & N. R. R., L. & N. Bldg., Louisville, Ky	June 1, 1909
Pfau, Julius Welch. Engr. of Constr., N. Y. C. R. R., Room 1101, Grand Central Station, New York City. (*Assoc. M., Dec. 2, 1903*)	Dec. 6, 1910
Pharr, Harry Nelson. 536 Randolph Bldg., Memphis, Tenn. (*Assoc. M., Oct. 3, 1900*)	June 6, 1905
Phelps, William Collins. 165 Broadway, Room 1026 A, New York City.	Oct. 2, 1907
Philbrick, Shirley Seavey. Engr. (Philbrick & Foster), Clarkston, Wash.	Dec. 5, 1911
Philips, James Harry. Prin. Asst. to Engr. and Supt. of Essex County Park Comm., 60 Clifton Ave., Newark (Res., 41 Hawthorne Ave., Glen Ridge), N. J	Feb. 6, 1907
Phillips, Alfred Edward. Prof., Civ. Eng., Armour Inst. of Technology, 1206 Morse Ave., Chicago, Ill	May 3, 1905
Phillips, Arthur Louis. Chf. Engr., The Cuba Co., Camagüey, Cuba	Nov. 4, 1903
Phillips, Asa Emory. Supt., Sewer Dept., D. C., District Bldg., Washington, D. C. (*Jun., Nov. 5, 1891; Assoc. M., Dec. 7, 1898*)	Sept. 4, 1901
Phillips, Frederick. Jacksonville, Fla. (*Jun., June 4, 1895; Assoc. M., April 4, 1900*)	Oct. 4, 1910
Phillips, Hiram. Cons. Hydr. and San. Engr., Third National Bank Bldg., St. Louis, Mo. (*Assoc. M., Jan. 3, 1894*)	Nov. 3, 1897
Phillips, Joseph Leslie. Mgr., Gold Rd. Min. & Ex. Co., 2159 West 25th St., Los Angeles, Cal	Nov. 3, 1897
Phillips, Richard Harvey. Cons. Engr., Security Bldg., St. Louis, Mo	Dec. 7, 1904
Phillips, William Renton. 419 Lumber Exchange Bldg., Portland, Ore.	June 1, 1909
Pickett, William Douglas. 228 Campsie St., Lexington, Ky	July 6, 1853
Pierce, Frederic Emery. Chf. of Constr., The New Jersey Zinc Co., 55 Wall St., New York City	Oct. 5, 1909
Pierce-Hope, John. Mgr., Guaqui to La Paz Ry., Casilla 280, La Paz, Bolivia	Dec. 5, 1906
Pierson, George Spencer. Civ., Hydr. and San. Engr., Kalamazoo, Mich.	June 5, 1889
Pihl, Olaf Ridley. 637 Wabash Bldg., Pittsburgh, Pa	Oct. 2, 1889
Pillsbury, Franklin Calhoun. Div. Engr., Massachusetts Highway Comm., 126 Massachusetts Ave., Boston, Mass	Aug. 31, 1909
Pitcher, Samuel Henry. 418 Main St., Worcester, Mass	Mar. 2, 1909
Pitman, Frederick Longfellow. Chf. Engr., O.-W. R. & N. Co., Third Dist., and West Coast Ry., 9th Floor, Paulsen Bldg., Spokane, Wash.	Oct. 5, 1909
Pitts, Thomas Dorsey. Div. Engr., Sewerage Comm., 904 American Bldg., Baltimore, Md. (*Jun., Dec. 7, 1897; Assoc. M., June 4, 1902*)	Oct. 4, 1910
Pitzman, Julius. 615 Chestnut St., St. Louis, Mo	Dec. 4, 1907
Plimpton, Arthur Leslie. Civ. Engr. in Chg. of Dept. of Civ. Eng., Boston Elev. Ry., 101 Milk St., Boston, Mass	May 6, 1896
Poetsch, Charles Julius. Cons. Engr., Mack Blk., Milwaukee, Wis. (*Jun., May 4, 1881*)	May 2, 1883

	Date of Membership
Poland, William Babcock. Vice-Pres. and Chf. Engr., Philippine Ry., Manila, Philippine Islands. (*Jun., Oct. 31, 1893; Assoc. M., May 3, 1899*)	Sept. 2, 1903
Polhemus, James Suydam. U. S. Asst. Engr., Custom House, Portland, Ore	Oct. 3, 1894
Polledo, Ysidoro. Manzaneda 16, Matanzas, Cuba. (*Jun., Jan. 2, 1889*).	Nov. 4, 1903
Polleys, William Vaughan. Box 95, Upper Darby, Pa	Jan. 3, 1906
Pollock, Clarence DuBois. Acting Chf. Engr., Highways, Borough of Manhattan, Room 1611, Park Row Bldg., New York City. (*Assoc. M., Jan. 8, 1902*)	April 4, 1905
Pond, Henry Otis. Tenafly, N. J	May 4, 1909
Pope, John Horton. Madeira-Mamoré Ry., 9 Rue Louis le Grand, Paris, France	Dec. 7, 1904
Pope, Willard. Vice-Pres. and Engr., The Canadian Bridge Co., Ltd., Walkerville, Ont., Canada	Oct. 5, 1904
Porter, Dwight. Prof. of Hydr. Eng., Mass. Inst. Tech., Boston, Mass.	Oct. 4, 1893
Porter, Henry Hobart. (Sanderson & Porter), 52 William St., New York City	June 3, 1903
Porter, Henry Tegmeyer. Chf. Engr., B. & L. E. R. R., Greenville, Pa.	April 1, 1903
Porter, Sam Graham. Chf. Engr., Arkansas Val. Sugar Beet & Irrigated Land Co., Holly, Colo. (*Assoc. M., Oct. 2, 1907*)	Dec. 5, 1911
Poss, Victor Henry. Cons. Engr., 615 Mechanics Inst. Bldg., San Francisco, Cal	April 5, 1910
Post, George Browne. 347 Fifth Ave., New York City	Sept. 2, 1896
Post, Henry Willis. Cons. Structural Engr., 30 West 38th St., New York City	Oct. 7, 1903
Post, Walter A. Pres., Newport News Shipbuilding & Dry Dock Co., Newport News, Va	Mar. 1, 1893
Potter, Charles Lewis. Lt.-Col., Corps of Engrs., U. S. A., 428 Custom House, St. Louis, Mo	April 1, 1903
Potter, Henry Witbeck. Office Engr., Tlahualilo Agri. Co., Tlahualilo, Dgo., Mexico	Dec. 5, 1888
Potter, Herbert Leroy. 165 Prospect Park West, Brooklyn, N. Y	Oct. 2, 1907
Potter, William Bancroft. Engr., Railway and Traction Dept., Gen. Elec. Co., Schenectady, N. Y	Mar. 2, 1904
Potts, Clyde. Civ. and San. Engr., 30 Church St., New York City. (*Jun., Dec. 3, 1901; Assoc. M., Oct. 4, 1905*)	June 30, 1910
Powell, Ambrose Vincent. Cons. Engr., 1007 Chamber of Commerce Bldg., Chicago, Ill	Feb. 6, 1901
Powell, Archibald Olin. Cons. Engr., 404 Central Bldg., Seattle, Wash.	Mar. 2, 1898
Power, George Coffin. Saticoy, Cal	Feb. 1, 1893
Powers, Cornelius Van Vorst. Div. Engr., Public Service Comm. for the First Dist., 103 East 125th St., New York City	Mar. 1, 1905
Powers, Joseph Allen. Pres., Powers & Mansfield Co., 280 River St., Troy, N. Y. (*Jun., April 2, 1884*)	Sept. 3, 1890
Pratt, Francis Everett. Chf. Engr., Arbuckle Bros., Jay St. Terminal, Brooklyn, N. Y	Sept. 5, 1911
Pratt, Mason Delano. Cons. Engr., 16 S. Second St., Harrisburg, Pa. (*Jun., Sept. 5, 1888; Assoc. M., Feb. 3, 1897*)	April 3, 1901
Pratt, Robert Winthrop. Cons., Civ. and San Engr., 2048 East 82d St., Cleveland, Ohio	June 6, 1911
Pratt, William Abbott. Cons. Engr., Waynesboro, Va	July 5, 1882
Preston, Charles Henry. Archt. and Structural Engr., 43 Broadway, Norwich, Conn	Oct. 5, 1909
Preston, Charles Henry, Jr. Cons. Engr., 136 Grand St., Waterbury, Conn. (*Assoc. M., Oct. 2, 1907*)	Sept. 6, 1910
Preston, Henry Wray. Engr., Elmira Plant, Empire Bridge Co., Elmira Heights, N. Y. (*Assoc. M., May 3, 1899*)	Sept. 3, 1907
Price, William Gunn. 512 Reis St., New Castle, Pa	April 3, 1895
Prichard, Henry Sewall. Am. Bridge Co., Frick Bldg., Pittsburgh, Pa.	Jan. 2, 1895
Prince, George Thomas. Cons. Engr., 522 Symes Bldg., Denver, Colo.	April 4, 1894
Prindle, Franklin Cogswell. Civ. Engr., U. S. N.; Rear-Admiral (*Retired*), 1752 Park Rd., Washington, D. C	Mar. 4, 1874
Prior, Charles Henry. 304 South 7th St., Minneapolis, Minn	Mar. 1, 1882
Pritchett, Charles Marcellus. Chf. Div. Engr., Bureau of Public Works, Manila, Philippine Islands. (*Assoc. M., Sept. 2, 1903*)	Jan. 4, 1910
Proal, Arthur Breese, Jr. Care, Robins Conveying Belt Co., Passaic, N. J	Mar. 7, 1906
Prout, Henry Goslee. First Vice-Pres. and Gen. Mgr., Union Switch & Signal Co., 30 Church St., New York City. (*Assoc., Nov. 6, 1872*)	Sept. 3, 1879
Pruyn, Francis Lansing. Vice-Pres., Underpinning Co., 290 Broadway, New York City. (*Jun., Dec. 1, 1896; Assoc. M., June 7, 1899*)	Mar. 2, 1909
Puffer, William Haselton. Guanajuato, Mexico	May 3, 1905
Puga, Guillermo Beltran y. Direccion de Obras Publicas, City of Mexico, D. F., Mexico	June 5, 1907
Pugh, DeWitt Pawling. Asst. Engr., P. R. R., Norristown, Pa	May 6, 1908

		Date of Membership
	Pugh, Marshall Rogers. (Pugh & Hubbard), 601 Witherspoon Bldg., Philadelphia, Pa. (*Assoc. M., Dec. 7, 1904*)	Nov. 2, 1908
	Purdon, Charles de la Cherois. Chf. Engr., St. Louis Southwestern Ry., 1342 Pierce Bldg., St. Louis, Mo	Mar. 3, 1886
	Purdy, Corydon Tyler. Everett Bldg., Union Sq. North, New York City. (*Jun., Feb. 2, 1887*)	Dec. 6, 1893
	Purdy, Samuel Moreau. Chf. Engr., E. E. Smith Contr. Co., 189 Fourth Ave. (Res., 470 Third St.), Brooklyn, N. Y	May 3, 1910
	Putnam, George Rockwell. Commr. of Lighthouses, Washington, D. C. (*Assoc. M., Feb. 1, 1899*)	June 3, 1903
	Quick, Alfred Merritt. Cons. Engr., 725 Munsey Bldg., Baltimore, Md. (*Assoc. M., Oct. 5, 1898*)	May 3, 1910
	Quilty, Thomas Frank. (John J. O'Heron & Co.), 229 North Wabash Ave., Chicago (Res., 419 South 64th Ave., Oak Park), Ill. (*Assoc., April 5, 1905*)	Sept. 5, 1911
	Quimby, Charles Henry, Jr. Res. Engr., N. Y., Westchester & Boston Ry., 105 Madison St., Mt. Vernon, N. Y. (*Assoc. M., Dec. 4, 1907*)	June 30, 1910
R.	Quimby, Henry Hodge. Cons. Bridge Engr., 3920 Girard Ave., Philadelphia, Pa	Sept. 3, 1890
	Quinby, Edwin Rufus. Chf. Engr., Con. Tel. & Elec. Subway Co., 66 Lafayette St., New York City	May 4, 1904
	Quinn, Richard. U. S. Asst. Engr., Honolulu, Hawaii	Mar. 2, 1904
	Quinton, John Henry. Cons. Engr., U. S. Reclamation Service, 601 Wright and Callender Bldg., Los Angeles, Cal	Feb. 7, 1900
	Quintus, John Charles. U. S. Asst. Engr., 540 Federal Bldg., Buffalo, N. Y	Jan. 2, 1889
	Raasloff, Harald de. 18 Burling Slip, New York City. (*Jun., Dec. 3, 1884*)	July 3, 1895
	Rabello, Cesar de Sá. Technical Director, Campanhia Brazileira de Energia Electrica, P. O. Box 883, Rio de Janeiro, Brazil	June 6, 1911
	Rablin, John Richard. Chf. Engr., Met. Park Comm., 14 Beacon St., Boston, Mass	Aug. 31, 1909
	Radenhurst, William Napier. 16 Scio St., Rochester, N. Y. (*Jun., July 7, 1875*)	July 7, 1880
	Raikes, Hugh Percival. Cons. Engr., 63 Temple Row, Birmingham, England. (*Assoc. M., June 6, 1906*)	July 1, 1909
	Ralston, John Chester. Cons. Engr., 2421 West Mission Ave., Spokane, Wash	Oct. 3, 1906
	Ramsey, Joseph, Jr. Pres., Ann Arbor R. R., 42 Broadway, New York City (Res., Hotel Alvord, East Orange, N. J.)	May 1, 1889
	Randall, Henry Irwin. Natron, Lane Co., Oregon	Feb. 7, 1906
	Randle, George Nelson. City Engr., City Hall, Sacramento, Cal	Feb. 2, 1909
	Randolph, Beverly Strother. Civ. and Min. Engr., Berkeley Springs, W. Va	May 2, 1888
	Randolph, Isham. Cons. Engr., 826 First National Bank Bldg., Chicago, Ill	Feb. 4, 1903
	Randolph, Lingan Strother. Prof., Mech. Eng., Va. Polytechnic Inst., Blacksburg, Va	Jan. 2, 1890
	Rankin, Edward Stevens. Engr., Dept. of Sewers and Drainage, City Hall, Newark, N. J	June 30, 1911
	Raster, Walther. Office Mgr., E. C. & R. M. Shankland, 1106 The Rookery, Chicago, Ill. (*Jun., Feb. 4, 1902; Assoc. M., Mar. 6, 1907*)	Dec. 6, 1910
	Rathman, Louis Henry. Asst. Engr., Bureau of Eng., Dept. of Public Works; Engr. in Chg., City Survey Div., 172 Cleveland Ave., Buffalo, N. Y	May 2, 1911
	Ray, Frederick George. Prin. Asst. Engr., U. S. Lake Survey, 211 Old Custom House, Detroit, Mich	April 6, 1909
	Ray, George Joseph. Chf. Engr., D., L. & W. R. R., Hoboken (Res., East Orange), N. J	June 3, 1908
	Raymer, Albert Reesor. Asst. Chf. Engr., Pitts. & Lake Erie R. R., Pittsburgh, Pa	Mar. 1, 1910
	Raymond, Alfred. Gen. Mgr., Drainage Dept., Sewerage and Water Board of New Orleans, 503 City Hall Annex (Res., 1444 State St.), New Orleans, La	Sept. 6, 1910
	Raymond, Charles Walker. Brig.-Gen., U. S. A. (*Retired*), Room 344, Bourse Bldg., Philadelphia, Pa	June 1, 1892
	Raymond, Charles Ward. Min. and Civ. Engr., 311 Inverness Bldg., Sacramento (Res., 2335 Pacific Ave., San Francisco), Cal. (*Jun., Nov. 7, 1877*)	April 7, 1886
	Raymond, William Galt. Prof., Civ. Eng.; Dean, Coll. of Applied Science, State Univ. of Iowa; Cons. Engr., Iowa City, Iowa	Oct. 3, 1894
	Rea, Samuel. First Vice-Pres., The P. R. R., 225 Broad St. Station, Philadelphia, Pa	June 4, 1884

MEMBERS R

	Date of Membership
Reaburn, De Witt Lee. Div. Engr., Los Angeles Aqueduct, Surrey, Cal. *(Assoc. M., April 6, 1904)*	Nov. 30, 1909
Read, Robert Leland. 68 Summer St., Malden, Mass.	Sept. 2, 1874
Reber, Henry Linton. Vice-Pres. and Gen. Mgr., Kinloch Telephone System, Kinloch Bldg., St. Louis, Mo.	May 1, 1904
Redlich, Carl. R. R. Oberbaurat, Wien IX Garnisongasse 3, Vienna, Austria	Sept. 7, 1904
Reed, David Abell. Cons. Engr., 423 Lyceum Bldg., Duluth, Minn.	Mar. 4, 1896
Reed, Melville Emerson. Cons. Engr., 414 Lewis Bldg., Portland, Ore.	Mar. 6, 1901
Reed, Paul Lyon. Civ. Engr., U. S. N., Bureau, Yards and Docks, Navy Dept., Washington, D. C.	July 9, 1906
Reed, Wendell Monroe. Dist. Engr., U. S. Reclamation Service, El Paso, Tex.	Oct. 5, 1904
Reed, William Boardman. Pres., O. & H. R. R., 420 East 25th St., New York City. *(Assoc. M., Feb. 6, 1895)*	May 1, 1901
Reeves, David. Pres., The Phœnix Iron Co. and Phœnix Bridge Co., 410 Walnut St., Philadelphia, Pa. *(Jun., April 1, 1874)*	May 3, 1882
Reeves, Harley Edson. U. S. Asst. Engr., Rock Falls, Ill.	Jan. 4, 1910
Reich, Phillip Jacob. Engr., Toledo Plant, Am. Bridge Co., Toledo, Ohio. *(Assoc. M., June 5, 1907)*	Dec. 5, 1911
Reichmann, Albert Ferdinand. Res. Engr., Am. Bridge Co., 1305 Commercial National Bank Bldg., Chicago, Ill. *(Jun., April 30, 1895; Assoc. M., Oct. 5, 1898)*	Mar. 4, 1903
Reimer, William Henri Vale. 52 North Maple Ave., East Orange, N. J.	Mar. 6, 1907
Renshaw, Alfred Howard. Noroton, Conn.	June 1, 1898
Reynders, John Van Wicheren. Vice-Pres., The Pennsylvania Steel Co., Steelton, Pa. *(Assoc. M., June 1, 1892)*	Mar. 3, 1897
Reynolds, Abraham Moreau. Engr. and Supt., Essex County Park Comm., 60 Clifton Ave., Newark, N. J.	Nov. 30, 1909
Rhett, Edmund Moore. Elec. Engr., Cent. of Ga. Ry., Savannah, Ga. *(Jun., Nov. 4, 1902)*	Oct. 4, 1910
Rhines, George Volney. Structural Engr. with Geo. S. Mills, Archt., 1234 Ohio Bldg., Toledo, Ohio. *(Assoc. M., June 3, 1903)*	Feb. 1, 1910
Riblet, Byron Christian. Pres., Riblet Tramway Co., 605 Empire State Bldg., Spokane, Wash.	July 1, 1908
Rice, Elton. Pres. and Gen. Mgr., The Massillon Bridge & Structural Co., Massillon, Ohio	Sept. 5, 1911
Rice, George Staples. Cons. Engr., 154 Nassau St., New York City	Feb. 1, 1882
Rice, Walter Percival. Cons. Engr. (The Walter P. Rice Eng. Co.), 606 Osborn Bldg., Cleveland, Ohio	Mar. 6, 1889
Rich, Edward Dunbar. Asst. Prof. in Civ. Eng., Univ. of Michigan, 837 East University Ave., Ann Arbor, Mich.	Nov. 4, 1908
Rich, Isaac. Asst. Engr., N. Y., N. H. & H. R. R., Room 469 South Station, Boston, Mass.	May 6, 1903
Richards, Albert Lennox. U. S. Asst. Engr., Care, U. S. Engr. Office, Rock Island, Ill.	Jan. 2, 1901
Richards, Frederick David. Room 311, City Hall, Cleveland, Ohio	Jan. 31, 1911
Richards, Joseph Thomas. Chf. Engr., M. of W., P. R. R., Broad St. Station, Philadelphia, Pa.	April 4, 1894
Richardson, Clifford. Cons. Engr., 30 Church St., New York City. *(Assoc., Oct. 4, 1892)*	Feb. 4, 1908
Richardson, Joshua Wilson. Chicoutimi, Que., Canada	Dec. 6, 1910
Richardson, Thomas Franklin. Chf. Civ. Engr., J. G. White & Co., Inc., 43 Exchange Pl., New York City (Res., 649 East 23d St., Brooklyn, N. Y.)	Nov. 4, 1885
Ricker, George Alfred. (Ricker & Minniss), 702 Ellicott Sq., Buffalo, N. Y. *(Jun., April 7, 1886; Assoc. M., May 1, 1895)*	April 3, 1901
Ricketts, Louis Davidson. Cananea, Sonora, Mexico	Oct. 5, 1904
Ricketts, Palmer Chamberlaine. Pres. of, and Prof. of Mechanics, Rensselaer Polytechnic Inst., Troy, N. Y. *(Assoc., Feb. 3, 1886)*	Oct. 5, 1887
Rickey, James Walter. Chf. Engr., Long Sault Development Co., Massena, N. Y. *(Assoc. M., Sept. 3, 1902)*	April 4, 1905
Rickon, Frederic John Henry. Rickon-Ehrhart Eng. & Constr. Co., 1859 Geary St., San Francisco, Cal.	Jan. 4, 1888
Ridgway, Arthur Osbourne. 608 Equitable Bldg., Denver, Colo.	Jan. 31, 1911
RIDGWAY, ROBERT. *(Director)*. Engr., Subway Constr., Public Service Comm., First Dist., 154 Nassau St., New York City. *(Jun., Feb. 1, 1888)*	June 3, 1903
Riegner, Wallace Berkley. Engr. of Bridges, P. & R. Ry., Reading Terminal, Philadelphia, Pa.	Sept. 7, 1904
Riffle, Franklin. Mgr., Iron and Pipe Depts., Dunham, Carrigan & Hayden Co., 130 Kansas St., San Francisco, Cal.	Nov. 7, 1888
Riggs, Henry Earle. Cons. Engr. (The Riggs & Sherman Co.), 613 Nasby Bldg., Toledo, Ohio (Res., 114 Fourteenth St., Ann Arbor, Mich.). *(Assoc. M., Oct. 4, 1893)*	April 1, 1896

	Date of Membership
Riggs, Morris John. Mgr., Toledo Plant, Am. Bridge Co., Toledo, Ohio..	Dec. 6, 1899
Righter, Addison Alexander. Director and Engr., John M. Ewen Co., 525 The Rookery, Chicago, Ill.	Jan. 4, 1910
Rights, Lewis Daniel. Contr. Mgr., Lewis F. Shoemaker & Co., 45 Broadway, New York City. (*Assoc. M., Mar. 5, 1902*)	Sept. 1, 1908
Ripley, Henry Clay. Caixa 336, Rio de Janeiro, Brazil	Oct. 7, 1896
Ripley, Herbert Lawrence. Engr., Constr., N. Y., N. H. & H. R. R., New Haven (Res., 542 Washington Ave., West Haven), Conn	Oct. 7, 1908
Ripley, John Wesley. Secy. and Treas., The Robbins-Ripley Co., 50 Church St., New York City	May 1, 1907
Ripley, Joseph. Member, Board of Cons. Engrs., New York State Canals, State Hall, Albany, N. Y	Sept. 4, 1901
Ripley, Theron Monroe. Barge Canal Res. Engr., Fulton, N. Y. (*Assoc. M., Nov. 6, 1901*)	Feb. 28, 1911
Rippey, Samuel Howard. Cons. Engr., Stephen Girard Bldg., Philadelphia (Res., Upsal St., West of Wayne Ave., Germantown), Pa	May 6, 1908
Riser, Knud Sophus. Cons., Civ. and Architectural Engr., 615 The Gilbert, Grand Rapids, Mich	Feb. 3, 1892
Ritchie, George Alexander. Hotel Metropolitano, Bogota, Colombia	May 6, 1908
Ritchie, James. Cons. Engr., 1943 East 107th St., Cleveland, Ohio	Nov. 5, 1890
Rittenhouse, Walter Britton. Paonia, Colo	April 6, 1909
Ritter, Louis E. (Ritter & Mott), 1707 Marquette Bldg., Chicago, Ill	Oct. 4, 1905
Rix, Edward Austin. Pneumatic Engr.; Pres., Rix Compressed Air & Drill Co., 219 Spear St., San Francisco, Cal	April 7, 1897
Robbins, Allan Appleton. Pres., Robbins-Ripley Co., 50 Church St., New York City. (*Assoc. M., Oct. 2, 1901*)	Sept. 6, 1904
Robbins, Samuel Bostwick. Cons. Irrig. Engr., P. O. Box 883, Great Falls, Mont	Sept. 6, 1905
Roberts, George Thomas. Contr., 401 D. S. Morgan Bldg., Buffalo, N. Y. (*Assoc. M., Sept. 3, 1902*)	Mar. 3, 1908
ROBERTS, PERCIVAL, JR. (*Director*). 717 Arcade Bldg., Philadelphia, Pa. (*Assoc., May 7, 1879*)	June 4, 1884
Roberts, Shelby Saufley. Div. Engr. of Constr., I. C. R. R., 135 Park Row, Chicago, Ill. (Res., 1454 Second St., Louisville, Ky.) (*Assoc. M., April 5, 1905*)	Jan. 7, 1908
Roberts, William Jackson. State Highway Commr., Olympia, Wash. (*Assoc. M., June 6, 1900*)	Sept. 3, 1907
Robertson, Marshall Pope. Member, State Board of Engrs. of La., 904 North Boulevard, Baton Rouge, La. (*Assoc. M., Mar. 5, 1902*)	Sept. 4, 1906
Robinson, Albert Alonzo. 900 Tyler St., Topeka, Kans	May 5, 1880
Robinson, Albert Fowler. Bridge Engr., A., T. & S. F. Ry. System, 1000 Railway Exchange Bldg., Chicago, Ill	Nov. 2, 1887
Robinson, Arthur Wells. 14 Phillips Sq., Montreal, Que., Canada	Feb. 3, 1892
Robinson, Edgar Franklin. Chf. Engr., B., R. & P. Ry, Rochester, N. Y.	June 6, 1911
Robinson, Erdis Geroska. Pres., S. W. Robinson & Son Co., 515 West First Ave. (Res., 355 West Ninth Ave.), Columbus, Ohio	Mar. 2, 1909
Robinson, George Loomis. Pres., New York Sewage Disposal Co., 37 East 28th St., New York City. (*Jun., April 5, 1904; Assoc. M., Mar. 7, 1906*)	Dec. 6, 1910
Robinson, John Mason. Asst. Chf. Engr., Madeira-Mamoré Ry., Manãos, Brazil	Nov. 1, 1910
Robinson, William Harper. City Engr., City Hall, Manila, Philippine Islands	Mar. 1, 1910
Rockwell, James Vincent. Civ. Engr., U. S. N.; Public Works Officer, U. S. Navy Yard, Charleston, S. C. (*Jun., April 3, 1900; Assoc. M., Feb. 4, 1903*)	Nov. 5, 1907
Rockwell, Samuel. Chf. Engr., L. S. & M. S. Ry., Cleveland, Ohio	Jan. 7, 1880
Rockwood, Arthur Jones. Cons. Engr. and Contr., 407 Cutler Bldg., Rochester, N. Y	Feb. 1, 1905
Rodd, Thomas. Chf. Engr., Penn. Lines W. of Pitts., Union Station, Pittsburgh, Pa	June 5, 1878
Rogers, Edwin Henry. City Engr. of Newton, City Hall, West Newton, Mass.	Jan. 2, 1907
Rogers, George Hamilton. 5 East 42d St., New York City	July 1, 1909
Rogers, Walter Alexander. Pres., Bates & Rogers Constr. Co., 885 Old Colony Bldg., Chicago, Ill. (*Jun., Sept. 10, 1891; Assoc. M., Nov. 3, 1897*)	April 4, 1900
Rohrer, Grant. Contr., 299 Broadway, New York City	July 1, 1909
Rohrer, Jacob Bomberger. Civ. Engr. and Contr., 336 North Duke St., Lancaster, Pa	Nov. 6, 1907
Rohwer, Henry. Cons. Engr., 700 Fullerton Bldg. (Res., 5646 Cates Ave.), St. Louis, Mo	April 1, 1903
Rollins, Charles Word. Chf. Engr., Neches Canal, China, Tex	April 5, 1910
Rollins, James Wingate, Jr. Pres., Holbrook, Cabot & Rollins, Corporation Contrs., 6 Beacon St., Boston, Mass	Nov. 7, 1900

MEMBERS R-S

	Date of Membership
Rommel, George, Jr. Chf. Engr., Board of Bond Trustees, Pensacola, Fla. (*Jun., Jan. 3, 1899; Assoc. M., Mar. 5, 1902*)	Oct. 2, 1906
Rood, Henry Martyn. 163 William St., Port Chester, N. Y.	Dec. 3, 1890
Ropes, Horace. 11 Chestnut Pl., Brookline, Mass.	Sept. 2, 1903
Rose, Charles Clemons. Supt., Coal Dept., The D. & H. Co., Scranton, Pa.	April 4, 1888
Rose, Rudolf Viedt. Eng. Asst., The Niagara Falls Power Co., and Canadian Niagara Power Co.; Res. Engr., Niagara Junction Ry., Niagara Falls, N. Y. (*Assoc. M., April 5, 1905*)	Feb. 28, 1911
Rosenberg, Theodore. Cons. Civ. and Hydr. Engr., Glenwood Springs, Colo.	Jan. 4, 1910
Rosencrans, Edwin John. Archt. (Jackson & Rosencrans), 50 Union Sq., New York City	May 7, 1902
Rosencrans, William Henry. Cons. Engr., 110 La Salle St., Chicago, Ill.	Oct. 5, 1898
Ross, Alexander Bell. Representative, Mo. Val. Bridge & Iron Co. of Leavenworth, Kans., City of Mexico, Mexico	May 2, 1900
Ross, Douglas William. Gen. Mgr. and Chf. Engr., Sacramento Val. Irrig. Co., Willows, Cal.	Mar. 1, 1899
Ross, Elmer Wayland. Asst. Engr., Bridge Dept., City Engr.'s Office, Providence, R. I. (*Jun., Mar. 5, 1890; Assoc. M., June 1, 1892*)	April 3, 1906
Ross, Florian Gaie. Cons. Engr., 307 Fifth Ave., Pittsburgh, Pa.	Dec. 2, 1903
Ross, James. 112 St. James St., Montreal, Que., Canada	Sept. 6, 1882
Rostock, John Henry. Prin. Asst. Engr., U. S. Engr. Office, 39 Whitehall St., Room 710, New York City	May 3, 1910
Rotch, William. 131 State St., Boston, Mass.	Mar. 5, 1873
Rourke, Louis Keegan. Commr. of Public Works, City Hall, Boston, Mass.	July 1, 1909
Rowell, George Freeman. Res. Engr., Chattanooga & Tennessee River Power Co., Guild, Tenn. (*Jun., May 4, 1897; Assoc. M., Jan. 2, 1901*).	Jan. 4, 1910
Rowland, Charles Bradley. Vice-Pres., The Continental Iron Works, West and Calyer Sts., Brooklyn, N. Y.	May 1, 1895
Rowland, Charles Leonard. Pres., Am. Welding Co., Carbondale, Pa.	Sept. 1, 1886
Rowland, Thomas Fitch, Jr. Pres., The Continental Iron Works, West and Calyer Sts., Brooklyn, N. Y.	Sept. 1, 1886
Rowse, Albert Owen. Asst. U. S. Engr., 208 West 7th St., Sterling, Ill.	Mar. 4, 1908
Roy, Robert Maitland. Gen. Mgr., The Hamilton Bridge Works Co., Ltd., Hamilton, Ont., Canada. (*Assoc. M., Oct. 3, 1900*)	Mar. 5, 1907
Ruddle, John. Cons. Engr., 631 Candler Bldg., Atlanta, Ga.	Oct. 3, 1894
Ruffin, Charles Lorraine. Care, Black Mountain Ry., Burnsville, N. C.	May 2, 1911
Ruggles, William Burroughs. 4620 Twenty-second Ave., N. E., Seattle, Wash.	April 7, 1886
RUNDLETT, LEONARD W. (*Director*). Commr. of Public Works, Moose Jaw, Sask., Canada	Sept. 5, 1883
Rushmore, David Barker. Chf. Engr., Power and Min. Dept., Gen. Elec. Co., Schenectady, N. Y.	Jan. 2, 1907
Russell, Richard Lord. Chf. Engr., Borough Development Co.; Chf. Engr., Chas. Cranford, 186 Remsen St., Brooklyn, N. Y. (*Jun., Feb. 5, 1895; Assoc. M., April 3, 1901*)	Sept. 4, 1906
Russell, Samuel Moorhead. Supt., Tol., Peoria & West. Ry., Union Station, Peoria, Ill.	Sept. 6, 1905
Russell, Silas Bent. Secy., Parker-Russell Min. & Mfg. Co., 508 Liggett Bldg., St. Louis, Mo. (*Jun., June 4, 1884*)	June 1, 1887
Russell, William Gardner. Altura, El Paso Co., Tex.	Oct. 4, 1905
Rust, Charles Henry. City Engr., Toronto, Ont., Canada	April 5, 1899
Rust, Henry Bedinger. Special Representative, The Babcock & Wilcox Co., 1110 Farmers Bank Bldg. (Res., 1177 Murray Hill Ave.), Pittsburgh, Pa. (*Assoc. M., April 6, 1898*)	April 1, 1903
Ruttan, Henry Norlande. City Engr., Winnipeg, Man., Canada	Jan. 4, 1893
Ryder, Ely Morgan Talcott. Engr., M. of W., Third Ave. R. R., 130th St. and Third Ave., New York City. (*Jun., Jan. 5, 1897*)	Dec. 5, 1906
Sabin, Alpheus Timothy. Columbus, Ky.	April 1, 1896
Sabin, Louis Carlton. Gen. Supt., St. Mary's Falls Canal, Sault Ste. Marie, Mich. (*Assoc. M., Oct. 4, 1893*)	May 7, 1902
Sackett, John Warren. Chf. Asst. Engr., U. S. Engr. Office, Jacksonville, Fla.	May 2, 1894
Safford, Arthur Truman. Asst. Engr., Proprietors of Locks and Canals, 66 Broadway, Lowell, Mass.	Sept. 6, 1899
Safford, Edward Stanley. Cons. Engr., Sharon, Mass.	Dec. 6, 1882
Safford, Harry Robinson. Care, Edgar Allen Am. Manganese Steel Co., 193 Michigan Ave., Chicago, Ill.	July 1, 1908
Sálas, Rafael Alvarez. Gen. Mgr., Cauca R. R., Cali, Colombia	Jan. 4, 1910
Samuel, George Frederick. First Asst. City Engr., Hyde Park Hotel, Chicago, Ill.	Sept. 6, 1910
Sanborn, Frank Berry. Prof. of Civ. Eng., Tufts Coll., Tufts College, Mass.	Oct. 1, 1902
Sanders, William Horatio. Cons. Engr., U. S. Reclamation Service, 915 Grand View Ave., Los Angeles, Cal.	Feb. 3, 1904

		Date of Membership
	Sando, Will Joseph. Cons. Engr., Milwaukee Club, Milwaukee, Wis.	Aug. 31, 1909
	Sanford, George Otis. Project Engr., U. S. Reclamation Service, Milk River Project, Malta, Mont. (*Assoc. M., Mar. 7, 1906*)	Jan. 4, 1910
	Sapp, Edward Howard. Civ. Engr., New York Shipbuilding Co., Camden (Res., Wenonah), N. J.	Sept. 6, 1905
	Sargent, Charles Daniel. P. O. Box 388, Cornwall, Ont., Canada	Feb. 28, 1911
	Sargent, Paul Dudley. Asst. Director, Office, Public Roads, U. S. Dept. of Agriculture, Washington, D. C.	Sept. 5, 1911
	Sarle, Oliver Perry. 146 Westminster St., Providence, R. I.	Jan. 2, 1901
	Saunders, William Lawrence. Pres., Ingersoll-Rand Co.; Editor, *Compressed Air,* 11 Broadway, New York City	Nov. 3, 1886
	Savage, Hiram Newton. Superv. Engr., Dept. of the Interior, U. S. Reclamation Service, Washington, D. C.; Address, Helena, Mont. (*Assoc. M., Mar. 7, 1894*)	Oct. 7, 1896
	Savage, John Richard. Chf. Engr., L. I. R. R., Jamaica, N. Y.	June 7, 1905
	Saville, Caleb Mills. Chf. Engr., Board of Water Commrs., City Hall, Hartford, Conn. (*Assoc. M., Nov. 6, 1895*)	Jan. 2, 1901
	Sawyer, Walter Howard. Hydr. Engr., and Agt., Union Water Power Co., 11 Lisbon St., Lewiston, Me.	May 2, 1906
	Sax, Percival Mosley. 1328 Chestnut St., Philadelphia, Pa. (*Jun., Jan. 31, 1893; Assoc. M., Jan. 3, 1900*)	April 3, 1901
	Sayles, Earle Willoughby. City Engr., Watertown, N. Y.	June 1, 1909
	Sayles, Robert Wilson. Prin. Asst. Engr. with Chas. W. Leavitt, Jr., 220 Broadway, New York City. (*Assoc. M., April 5, 1905*)	May 5, 1908
	Scaife, William Lucien. Scaife Foundry & Machine Co., 313 Sixth Ave., Pittsburgh, Pa.	Dec. 3, 1890
	Scammell, John Kimball. Dist. Engr., Public Works, Canada, Box 321 Saint John, N. B., Canada. (*Assoc. M., June 4, 1902*)	Sept. 5, 1911
	Scarborough, Francis Winthrop. Engr. and Archt. (Scarborough & Howell, Inc.), 723 E. Main St., Richmond, Va. (*Jun., Sept. 3, 1890; Assoc. M., Mar. 6, 1895*)	Feb. 2, 1904
	Schaeffer, Amos. Cons. Engr., Borough of the Bronx, 177th St. and Third Ave., Bronx, New York City. (*Assoc. M., Feb. 3, 1904*)	Feb. 6, 1906
	Schall, Frederick Edward. Bridge Engr., Lehigh Val. R. R., South Bethlehem, Pa.	Oct. 1, 1902
	Scherer Clinton Lyter. City Engr., Beaumont, Tex.	Nov. 8, 1909
	Schermerhorn, Richard, Jr. Landscape Archt., 347 Fifth Ave., New York City. (*Assoc. M., July 9, 1906*)	Oct. 3, 1911
	Schick, James Reese. Engr., Branch Lines, N. & W. Ry. (Res., 915 Nelson St.), Roanoke, Va.	Mar. 1, 1910
	Schildhauer, Edward. Elec. and Mech. Engr., Isthmian Canal Comm., Culebra, Canal Zone, Panama	April 4, 1911
	Schlecht, Walter William. Care, Porto Rico Irrig. Service, Guayama, Porto Rico	April 6, 1909
	Schmidt, Max Eberhardt. Pres. and Chf. Engr., Continuous Transit Securities Co., 45 Broadway, New York City	May 7, 1879
	Schnauber, Frank Justus. 516 Kirk Bldg., Syracuse, N. Y.	Mar. 6, 1907
	Schneeweiss, Adolph Eugene. Engr., John W. Ferguson Co., Paterson, N. J.	Oct. 5, 1909
N. R.	SCHNEIDER, CHARLES CONRAD. (*Past-President*). Cons. Engr., Pennsylvania Bldg., Philadelphia, Pa.	Feb. 6, 1884
	Schneider, Edward John. Contr. Mgr., U. S. Steel Products Co., Bridge and Structural Dept., 609 Rialto Bldg., San Francisco, Cal. (*Assoc., July 9, 1906*)	Nov. 8, 1909
	Schofield, Hiram Abif. Dist. Mgr., Pittsburgh Testing Laboratory, Room 906, Crozer Bldg., Philadelphia, Pa.	Oct. 7, 1896
	Schreiber, John Martin. Engr., M. of W., Public Service Ry., Public Service Bldg., Newark, N. J. (*Assoc. M., June 5, 1907*)	Nov. 30, 1909
	Schroeder, Christoffer. With Haskell & Barker Car Co., Michigan City, Ind. (Res., 6509 LaFayette Ave., Chicago, Ill.)	June 1, 1909
	Schubert, Frederick Celestine. U. S. Asst. Engr., Dalles-Celilo Canal, 802 Couch Bldg., Portland, Ore. (*Assoc. M., June 5, 1907*)	Feb. 2, 1909
	Schultz, Albert Louis. Cons. Engr., 817 North Highland Ave., Pittsburgh, Pa.	Sept. 4, 1901
	Schultze, Paul. City Engr., Troy, N. Y. (*Assoc. M., Nov. 2, 1898*)	June 5, 1901
	Schulz, Walter Frederick. Engr. of Constr., Memphis Union Station Co., 681 Rayburn Boulevard, Memphis, Tenn.	Oct. 4, 1910
	Schulze, Henry Atherton. Archt., 512 East 17th St., East Oakland, Cal.	Oct. 2, 1907
R. R.	Schuyler, James Dix. Cons. Engr., Suite 1115, Union Trust Bldg., Los Angeles, Cal.	Dec. 6, 1882
	Scofield, Edson Mason. Pres., Scofield Eng. Co., Philadelphia, Pa. (*Assoc. M., April 1, 1896*)	May 2, 1905
	Scofield, Glenn Mason. Cons. Engr., 1324 Arcade Bldg., Philadelphia, Pa.	Sept. 7, 1904
	Scorgie, James Cruickshank. Supt., Mount Auburn Cemetery, Cambridge, Mass.	Nov. 4, 1908
	Scott, Addison Moffat. Charleston, Kanawha Co., W. Va.	June 2, 1886

		Date of Membership
	Scott, Dunbar Doolittle. Cons. Engr., Dept. of Precision Instruments, Bausch & Lomb Optical Co., Rochester, N. Y.	Dec. 5, 1911
	Scotten, Frank. Supt., Constr. Dept., Great Falls Water Power & Townsite Co., Great Falls, Mont.	Aug. 31, 1909
	Scovill, Edward Tracy. Dansville, N. Y.	Sept. 6, 1876
	Scripture, Arthur Marquis. New Hartford, N. Y. *(Assoc. M., June 3, 1896)*	Jan. 5, 1904
	Seaman, Henry Bowman. Cons. Engr., 165 Broadway, New York City. *(Jun., June 2, 1886)*	Dec. 7, 1887
	Searles, William Henry. Cons. Engr., Elyria, Ohio	July 2, 1873
N.	Seddon, James Alexander. Address unknown	Nov. 2, 1898
	Selander, John Einar. Care, Baker & Shelford, Cons. Engrs., Westminster, London, England	Nov. 4, 1908
	Sellew, Francis Libby. Project Engr., U. S. Reclamation Service, Yuma, Ariz. *(Assoc. M., Dec. 5, 1906)*	July 1, 1909
	Seltzer, Harry Kent. Engr. of Constr., Union Bridge & Constr. Co., 903 Sharp Bldg., Kansas City, Mo. *(Jun., Feb. 4, 1896; Assoc. M., Jan. 2, 1901)*	April 3, 1906
	Sengoku, Mitsugu. 21 Fujimicho Azabu, Tokyo, Japan	June 4, 1890
	Serber, David Charles. Structural Engr. to State Archt., Albany, N. Y.	April 6, 1909
	Sergeant, George, Jr., (Sergeant-Maxwell Co.), 103 Park Ave., New York City	April 2, 1902
	Seurot, Paul Albert. 199 North Grove St., East Orange, N. J. *(Jun., April 30, 1895; Assoc. M., Oct. 4, 1899)*	Nov. 1, 1904
N.	Sewell, John Stephen. Vice-Pres. and Gen. Mgr., Alabama Marble Co., Gantts Quarry, Ala	April 5, 1905
	Shailer, Robert Ames. Cons. Engr., 101 Tremont St., Room 304, Boston, Mass	Mar. 3, 1880
	Shand, Gadsden Edwards. 1831 Pendleton St., Columbia, S. C.	Nov. 7, 1906
	Shand, James. Cia Constructora de Ferrocarriles, S. A., Apartado 1290, City of Mexico, D. F., Mexico	Oct. 2, 1907
	Shankland, Edward Clapp. (E. C. & R. M. Shankland), 1106 Rookery, Chicago, Ill	Feb. 5, 1890
	Shankland, Ralph Martin. 1106 Rookery Bldg., Chicago, Ill	Mar. 1, 1899
	Shanks, Oscar. Swift Canadian Co., 13 Alexander St., Vancouver, B. C., Canada	July 9, 1906
	Shanly, James Moore. 316 Prince Arthur St., West, Montreal, Que., Canada	July 6, 1887
	Shannahan, John Newton. Railway Mgr., J. G. White & Co., 43 Exchange Pl., New York City. *(Jun., Oct. 4, 1898; Assoc. M., Mar. 6, 1901)*	May 5, 1908
	Shattuck, Orville Frank. City Engr., Greeley, Colo	July 1, 1908
	Shaw, Arthur Monroe. Engr. and Res. Mgr., Phillips Land Co., 323 Hibernia Bldg., New Orleans, La. *(Assoc. M., Jan. 3, 1906)*	Sept. 5, 1911
	Shaw, Enos Larkin. 1105 Monadnock Blk., Chicago, Ill. *(Jun., Oct. 3, 1893; Assoc. M., June 1, 1898)*	Mar. 6, 1906
	Shaw, George Harry Thornton. Apartado No. 1979, City of Mexico, Mexico.	Oct. 4, 1910
	Shaw, Granville Wheaton. P. O. Box 496, Louisville, Ky	Oct. 5, 1887
	Shaw, Sumner Farnham. Chf. Engr., Location, Brazil Ry., São Paulo, Brazil	Oct. 3, 1894
	Sheal, Robert Erwin, Engr., Care, The Wellman-Seaver-Morgan Co., Cor., Central and Giddings Aves., Cleveland, Ohio	Oct. 4, 1905
	Shearwood, Frederick Perry. Dominion Bridge Co., Montreal, Que., Canada	Oct. 7, 1903
	Shedd, Edward Whitten. Civ. and Hydr. Engr., 146 Westminster St., Providence, R. I.	May 6, 1903
	Shedd, Frank Edson. Vice-Pres. and Chf. Engr., Lockwood, Greene & Co., 93 Federal St., Boston, Mass	Feb. 6, 1907
	Shedd, Joel Herbert. Cons. Engr., Providence, R. I.	Sept. 15, 1869
	Shenehon, Francis Clinton. Dean, Coll. of Eng., Univ. of Minnesota, Minneapolis, Minn	May 7, 1902
	Shepard, David Chauncey. 324 Dayton Ave., St. Paul, Minn	May 2, 1883
	Shepard, Henry Hudson. Asst. Gen. Supt., South Buffalo Ry., Buffalo, N. Y.	Feb. 5, 1908
	Shepherd, Frank Cummings. With James Stewart & Co., Brewerton, N. Y. *(Assoc. M., Oct. 5, 1904)*	Feb. 1, 1910
	Sheppard, Charles Alfred. 115 Purcell St., Edwardsville, Ill	Nov. 30, 1909
	Sherman, Charles Winslow. Prin. Asst. Engr. with Metcalf & Eddy, Cons. Engrs., 14 Beacon St., Boston, Mass. *(Jun., Oct. 8, 1891; Assoc. M., May 2, 1900)*	Feb. 4, 1903
	Sherman, Edward Clayton. 6 Beacon St., Boston, Mass. *(Assoc. M., Jan. 3, 1906)*	Feb. 1, 1910
	Sherman, Herbert Ellwood. Asst. Engr. in Chg. of Dept. of Street Lines, City Engr.'s Office, Providence, R. I.	Mar. 7, 1900

	Date of Membership
Sherman, LeRoy Kempton. Engr. and Contr., 3046 West 36th St. (Res., 6231 Rhodes Ave.), Chicago, Ill.	Sept. 6, 1910
Sherman, Richard Willette. Chf. Engr., Conservation Comm., Albany, N. Y.	Oct. 6, 1886
Sherman, Walter Justin. Cons. Engr. (The Riggs & Sherman Co.), 613 The Nasby Bldg., Toledo, Ohio	May 4, 1909
Sherrerd, John Maxwell. Gen. Sales Agt., Taylor Iron & Steel Co., 340 Spring Garden St., Easton, Pa.	July 10, 1907
Sherrerd, Morris Robeson. Chf. Engr., Dept. of Public Works, City Hall, Newark, N. J. *(Assoc. M., May 3, 1893)*	May 6, 1896
Shipman, Eugene Hicks. Supt., Lehigh & New England R. R.; Canal Supt., Lehigh Coal & Nav. Co. (Res., 917 Delaware Ave.), South Bethlehem, Pa.	May 2, 1911
Shiraishi, Naoji. Care, Branch Office, Mitsu Bishi Co., Kobe, Japan	Oct. 4, 1899
Shirley, Henry Garnett. Roads Engr., Baltimore County, Towson, Md.	June 30, 1911
Shmeleff, Theodor Semenovitch. Engr., Russian Imperial Civ. Service, Novorossiisk, Caucasus, Russia	Sept. 7, 1892
Shoemaker, Louis Henry. Engr. in Chg., Design, Am. Bridge Co., Frick Bldg., Pittsburgh, Pa. *(Assoc. M., Oct. 4, 1899)*	Sept. 6, 1910
Shoemaker, Marshall Ney. Cons. Engr., 722 Union Bldg., Newark, N. J. *(Assoc. M., April 1, 1903)*	Jan. 3, 1911
Shuman, Edward Peter. Div. Engr., Bureau of Public Works, Manila, Philippine Islands	Oct. 2, 1907
Sibert, William Luther. Maj., Corps of Engrs., U. S. A.; Supervisory Engr., Dept. of Constr. and Eng., Isthmian Canal Comm., Culebra, Canal Zone, Panama	June 2, 1897
Silliman, Charles. 926 Nelson St., Roanoke, Va.	Mar. 1, 1910
Silva Freire, Victor da. City Chf. Engr.; Prof., Polytechnic School, P. O. Box 18, São Paulo, Brazil	Jan. 3, 1906
Simpson, George Frederic. Asst. Engr., Rapid Transit R. R. Comm., 400 Convent Ave., New York City	Mar. 2, 1887
Simpson, George Hume. 434 Shady Ave., Pittsburgh, Pa.	Oct. 6, 1880
Sims, Alfred Varley. Cascade, Va.	Mar. 4, 1896
Sims, Clifford Stanley. Second Vice-Pres. and Gen. Mgr., Delaware & Hudson Co., Albany, N. Y.	April 1, 1903
Simson, David. Ickleford Manor, Hitchin, Herts, England	Jan. 8, 1902
Sinclair, Frank Oscar. Cons. Engr., Public Service Comm. of Vermont, Burlington, Vt.	Nov. 6, 1901
Sinks, Frank Forrest. Company Engr., F. T. Crowe & Co., Globe Bldg., Seattle, Wash. *(Assoc. M., May 2, 1906)*	June 4, 1907
Sirrine, Joseph Emory. Box 581, Greenville, S. C. *(Jun., June 20, 1893; Assoc. M., May 4, 1898)*	May 6, 1903
Sjöström, Ivar Ludwig. Vice-Pres., United States Worsted Co., Lawrence, Mass. *(Jun., Sept. 6, 1892)*	Sept. 1, 1897
Skilton, George Steele. Asst. Engr., Dept. of Water Supply, Gas and Electricity of City of New York, Borough of Brooklyn (Res., Rockville Center), N. Y.	Sept. 7, 1881
Skinner, Frank Woodward. Associate Editor, *Engineering Record*, 239 West 39th St., New York City	Sept. 1, 1886
Skinner, John Franklin. Prin. Asst. to City Engr., 52 City Hall (Res., 31 Somerset St.), Rochester, N. Y.	April 4, 1906
Slifer, Hiram Joseph. Gen. Mgr., C. G. W. R. R., Gas Bldg., Chicago, Ill.	June 5, 1907
Sloan, David. Cons. Engr., MacArthur Bros. Co., 810 Fisher Bldg., Chicago, Ill.	Jan. 1, 1896
Sloan, William Griffith. Chf. Engr., MacArthur Bros. Co., 11 Pine St., New York City	Dec. 1, 1908
Slocum, Charles Mills. City Engr., 43 Bridge St., Springfield, Mass.	May 5, 1897
Smead, Raphael Chart. U. S. Asst. Engr., Federal Bldg., Dallas, Tex.	Feb. 1, 1905
Smetters, Samuel Tupper. Asst. Bridge Engr., The San. Dist. of Chicago, 76 West Monroe St. (Res., 6071 Jefferson Ave.), Chicago, Ill.	Sept. 6, 1910
Smith, Augustus. Pres., Bergen Point Iron Works, Foot of West 5th St., Bayonne, N. J.	June 4, 1902
Smith, Cecil Brunswick. Care, Smith, Kerry & Chace, Confederation Life Bldg., Toronto, Ont., Canada	Mar. 1, 1905
Smith, Charles William. 393 Lewis Ave., Brooklyn, N. Y. *(Assoc. M., April 5, 1893)*	Dec. 1, 1903
Smith, Edwin Foster. Cons. Engr., 602 Commonwealth Bldg., Philadelphia, Pa.	June 5, 1895
Smith, Edwin George. Gen. Supt., Westmoreland Coal Co., Irwin, Pa.	June 30, 1911
Smith, Eugene Raymond. Islip, Suffolk Co., N. Y. *(Jun., May 2, 1888)*	May 1, 1901
Smith, Francis Betts. In Chg. of Constr., Pearl Harbor Dry Dock, for San Francisco Bridge Co., 1479 Thurston Ave., Honolulu, Hawaii	Jan. 2, 1907
Smith, Francis Pitt. Chemical and Cons. Paving Engr. (Dow & Smith), 24 East 21st St., New York City	Nov. 30, 1909
Smith, Gilman Walter. Div. Erecting Mgr., Am. Bridge Co. of N. Y., 1332 Commercial National Bank Bldg., Chicago, Ill.	Mar. 2, 1909

	Date of Membership
Smith, Harradon Sterling. Cons. Engr. (Smith & Welles), Coal Exchange Bldg., Wilkes-Barre, Pa. (*Assoc. M., Nov. 1, 1905*)	April 5, 1910
Smith, Henry Clement. Div. Engr., Phila. Div., P. & R. Ry., Philadelphia, Pa.	Oct. 2, 1901
Smith, Henry DeWitt. 201 East Rusk St., Marshall, Tex.	Dec. 6, 1893
Smith, Howard Everett. Res. Engr., N. Y. State Dept. of Highways, Griffin Bldg., Syracuse, N. Y.	Nov. 6, 1907
Smith, John Herman. Engr., Idaho North. Ry., Nampa, Idaho	Nov. 7, 1906
Smith, Jonas Waldo. Chf. Engr., Board of Water Supply of the City of New York, 165 Broadway, New York City. (*Assoc. M., Oct. 5, 1892*)	April 5, 1899
Smith, Layton Fontaine. Representative, Trussed Concrete Steel Co. of Detroit, Mich., 513 North Charles St. (Res., 2901 Calvert St.), Baltimore, Md. (*Assoc. M., June 5, 1907*)	April 5, 1910
Smith, Leonard Charles Lindsay. Cons. Engr., Queensboro Corporation Bldg., Long Island City, N. Y.	Mar. 6, 1901
Smith, Leonard Sewall. Associate Prof. of Topographic and Road Eng., Univ. of Wisconsin, Madison, Wis. (*Assoc. M., June 2, 1897*)	Feb. 28, 1911
Smith, Merritt Haviland. Deputy Chf. Engr., Board of Water Supply, City of New York, 165 Broadway, New York City (Res., Kensico, N. Y.). (*Jun., June 5, 1889*)	April 3, 1907
Smith, Miller Armstrong. Cons. and Contr. Engr. (Smith & Davis), 512 Lonja Bldg., Havana, Cuba	Oct. 6, 1886
Smith, Oberlin. Pres., Ferracute Machine Co., "Lochwold," Bridgeton, N. J.	Sept. 3, 1884
Smith, Robert Colfax. Gen. Supt., E. C. & R. M. Shankland, Engrs., 1106 Rookery Bldg., Chicago, Ill.	July 9, 1906
Smith, Stewart Kedzie. Cons. Engr., Room 1317, Wright Bldg., St. Louis, Mo.	April 6, 1904
Smith, T. Guilford. Regent of the Univ. of State of New York, 203 Ellicott Sq., Buffalo, N. Y.	Sept. 6, 1871
Smith, Walter Mickle. Designing Engr., Board of Water Supply, 165 Broadway, New York City. (*Assoc. M., Oct. 2, 1901*)	April 3, 1906
Smith, William Charles. Chf. Engr., Idaho & Wash. North. R. R., Spirit Lake, Idaho	Sept. 4, 1901
Smith, William Sooy. P. O. Box 801, Medford, Ore.	Jan. 17, 1872
Smith, Willis Roswell. Care, The Arnold Co., 105 South La Salle St., Chicago, Ill.	Mar. 4, 1908
Smoot, Edgar Kenneth. Concessionario Obras del Puerto de Manzanillo, 5ª Balderas 70, City of Mexico, Mexico	Feb. 2, 1898
Snell, Thomas Cullen Bryant. Structural Engr., National Board of Fire Underwriters, 464 Whalley Ave., New Haven, Conn.	July 10, 1907
Snook, Thomas Edward. 73 Nassau St., New York City	Mar. 3, 1897
Snow, Charles Henry. Dean, School of Applied Science, New York Univ., Univ. Grounds, Morris Heights, New York City. (*Assoc. M., Feb. 1, 1893*)	Sept. 2, 1896
Snow, Frank Herbert. Chf. Engr., State Dept. of Health, Harrisburg, Pa. (*Assoc. M., June 4, 1895*)	May 3, 1904
Snow, Franklin Augustus. Contr. for Public Works, 178 Devonshire St., Boston, Mass.	Jan. 4, 1905
Snow, Jesse Baker. 330 South Lefferts Ave., Richmond Hill, N. Y.	Oct. 2, 1907
SNOW, JONATHAN PARKER. (*Director*). Cons. Engr., 18 Tremont St., Boston, Mass.	June 3, 1885
Snow, William Pliny. 30 Woodbine St., Auburndale, Mass.	Feb. 5, 1902
Snyder, Baird, Jr. Cons. Engr., 610 Mahantonga St., Pottsville, Pa.	Mar. 2, 1904
Snyder, Christopher Henry. Contr. Mgr., San Francisco Office of Milliken Bros., New York, 607 Humboldt Bank Bldg., San Francisco, Cal.	Oct. 2, 1901
Snyder, George Duncan. Prin. Asst. Engr., Hudson & Manhattan R. R., 30 Church St., New York City. (*Assoc. M., Nov. 6, 1895*)	Sept. 4, 1901
Somerville, Robert. Asst. Chf. Engr., Board of Miss. Levee Commrs., Greenville, Miss.	June 1, 1887
Somner, Francis George. Div. Engr., California Highway Comm., Willits, Cal.	Sept. 5, 1911
Sonderegger, Arthur Ludwig. 635 Central Bldg., Los Angeles, Cal.	Oct. 5, 1909
Sonne, Otto. Civ. and Landscape Engr., 132 Nassau St., New York City	Sept. 7, 1887
Sooysmith, Charles. Cons. Engr., 71 Broadway, New York City	May 5, 1886
Soper, George Albert. Cons. San. Engr., 29 Broadway, New York City. (*Assoc. M., Feb. 6, 1901*)	April 4, 1905
Sorzano, Julio Federico. Cons. Engr., 52 Broadway, New York City (Res., 228 Garfield Pl., Brooklyn, N. Y.)	Sept. 3, 1884
Souder, Harrison. Gen. Supt., Cornwall Ore Bank Co., Cornwall, Lebanon Co., Pa.	Jan. 6, 1904
Soulé, Frank. Prof. Emeritus of Civ. Eng., Univ. of California, 2511 Hillegass Ave., Berkeley, Cal.	Mar. 1, 1905
Soule, Howard. Box 254, Syracuse, N. Y.	Mar. 17, 1869
Souther, Henry. Cons. Engr.; Pres., The Henry Souther Eng. Co., Hartford, Conn.	Dec. 4, 1907

	Date of Membership
Spalding, Frederick Putnam. Prof. of Civ. Eng., Univ. of Missouri, 901 Virginia Ave., Columbia, Mo.	Dec. 2, 1891
Spaulding, Charles Lincoln. Res. Engr., Hudson Dist., Elec. Zone, N. Y. C. & H. R. R. R., 85 Main St., Yonkers, N. Y.	April 1, 1908
Speakman, Richard Edward. City Engr., Brandon, Man., Canada	Jan. 4, 1910
Spear, Walter Evans. Dept. Engr., Board of Water Supply of the City of New York, 250 West 54th St., New York City. (*Assoc. M., Feb. 3, 1904*)	Mar. 2, 1909
Spencer, John Clark. Cons. and Contr. Engr., 1024 Rockefeller Bldg., Cleveland, Ohio. (*Assoc. M., May 6, 1896*)	Dec. 6, 1904
Sperry, Henry Muhlenberg. Sales Mgr., Gen. Ry. Signal Co., P. O. Box 1052, Rochester, N. Y.	Nov. 6, 1901
Spicer, Vibé Kierulff. Gen. Mgr., Ry. Signal Co. of Canada, Ltd., Lachine, Que., Canada	June 5, 1895
Spilsbury, Edmund Gybbon. Cons. Engr., 45 Broadway, New York City	Dec. 7, 1892
Spofford, Charles Milton. Hayward Prof. of Civ. Eng., Mass. Inst. Tech., Boston, Mass. (*Assoc. M., June 4, 1902*)	June 6, 1905
Spooner, Allen Newhall. 159 Ocean Ave., New Dorp, N. Y.	Dec. 5, 1900
Spooner, Herman Winslow. Civ. Engr., Water Dept., 6 Proctor St., Gloucester, Mass.	Jan. 3, 1906
Sprague, Ernest Marshall. 1542 Rockefeller Bldg., Cleveland, Ohio	Oct. 3, 1906
Sprague, Frank Julian. Cons. Engr., 165 Broadway, New York City	June 1, 1904
Sprague, Norman Salisbury. Supt., Bureau of Constr., City Hall, Pittsburgh, Pa. (*Assoc. M., July 10, 1907*)	May 31, 1910
Spring, *Sir* Francis Joseph Edward. Chairman, Port Trust, Harbor, Madras, India	Jan. 3, 1894
Staats, John Henry. Vice-Pres. and Treas., R. P. & J. H. Staats, Engrs. and Contrs., 29 Broadway, New York City	Mar. 5, 1884
Staats, Robert Parker. Civ. Engr. and Contr. (R. P. & J. H. Staats), 29 Broadway, New York City. (*Jun., Nov. 3, 1875*)	July 1, 1885
Stacpoole, Stephen Westropp. Cons. Engr., 3ª Avenida de la Libertad No. 5, Orizaba, Vera Cruz, Mexico. (*Assoc. M., May 6, 1896*)	Sept. 4, 1901
Staley, Cady. Care, Case School of Applied Science, Cleveland, Ohio	Mar. 17, 1869
Stanford, Homer Reed. Civ. Engr., U. S. N., Bureau of Yards and Docks, Navy Dept., Washington, D. C. (*Jun., Oct. 1, 1890; Assoc. M., Nov. 7, 1894*)	Sept. 4, 1901
STANIFORD, CHARLES WILKINSON. (*Director*). Chf. Engr., Dept. of Docks and Ferries, Pier A, North River, New York City	May 7, 1890
Stanley, Orrin Elmore. Cons. Engr., Chamber of Commerce Bldg., Portland, Ore. (*Assoc. M., Oct. 7, 1908*)	May 31, 1910
Stanton, Frank McMillan. Min. Engr., 208 Fifth Ave., New York City	Feb. 1, 1899
Stanton, Robert Brewster. Civ. and Min. Engr., 32 Nassau St., Room 557, New York City	Sept. 1, 1880
Starrett, Milton Gerry. Cons. Engr., 100 Broadway, New York City	Jan. 3, 1900
Stauffer, David McNeely. 264 Palisade Ave., Yonkers, N. Y.	Sept. 2, 1874
Stayton, Edward Moses. 407 East Kansas St., Independence, Mo. (*Assoc. M., Feb. 4, 1903*)	Nov. 5, 1907
N. STEARNS, FREDERIC PIKE. (*Past-President*). Cons. Engr., 1 Ashburton Pl., Boston, Mass.	Oct. 2, 1878
Steece, Emmet Abner. Supt. of Constr., U. S. Public Bldgs., Greenwood, Miss. (*Assoc. M., Dec. 4, 1901*)	Mar. 1, 1904
Stephens, Clinton F. 602 Roe Bldg., St. Louis, Mo.	Sept. 5, 1877
Stephenson, James, Jr. Cons. Engr., Room 601, Idaho Bldg., Boise, Idaho	April 5, 1910
Stern, Eugene Washington. Cons. Engr., 103 Park Ave., New York City.	Mar. 3, 1897
Stern, Isaac Farber. Cons. Engr., 315 Old Colony Bldg., Chicago, Ill.	April 1, 1908
Stevens, Frank Stoddard. Engr., M. of W., P. & R. Ry., Reading, Pa.	Oct. 3, 1883
Stevens, Horace Edward. Director, Winston Bros. Co., Contrs., Minneapolis (Res., 530 Grand Ave., St. Paul), Minn. (*Jun., Nov. 1, 1876*)	April 4, 1888
Stevens, Howard Eveleth. Bridge Engr., N. P. Ry., St. Paul, Minn.	April 6, 1909
Stevens, John Frank. Waldorf-Astoria Hotel, New York City	June 6, 1888
Stewart, John Muirhead. Asst. Engr., Dept. of Docks and Ferries, East 24th St. Office, New York City. (*Jun., Mar. 2, 1887*)	Jan. 4, 1888
Stewart, Robert Dee. Supt. and Chf. Engr., Laramie, Hahn's Peak & Pacific Ry., Laramie, Wyo.	Nov. 1, 1905
Stickle, Horton Whitefield. Capt., Corps of Engrs., U. S. A., Wilmington, N. C.	Oct. 4, 1910
Stickney, George Fetter. Superv. Engr., New York State Barge Canal, Barge Canal Office, Albany, N. Y. (*Jun., May 1, 1894; Assoc. M., April 5, 1899*)	Sept. 4, 1906
Stillwell, Lewis Buckley. 100 Broadway, New York City	Oct. 2, 1901
Stockett, Alfred Walton. Gen. Mgr., The Simmer & Jack Proprietary Mines, Ltd., P. O. Box 192, Germiston, Transvaal, South Africa. (*Assoc. M., Jan. 1, 1896*)	Sept. 5, 1911
Stoddard, George Caleb. Civ. and San. Engr., 215 West 125th St., New York City	April 4, 1900

	Date of Membership
Stone, Everett Edward. 694 State St., Springfield, Mass	May 4, 1904
Stone, Henry Morton. Div. Engr., C., R. I. & P. Ry., Little Rock, Ark.	April 3, 1907
Storey, William Benson, Jr. Vice-Pres., A., T. & S. F. Ry., 1023 Railway Exchange, Chicago, Ill	Jan. 2, 1889
Storrow, Samuel. Civ. and Min. Engr., 906 Wright & Callender Bldg., Los Angeles, Cal. (*Jun., Sept. 10, 1891; Assoc. M., Oct. 2, 1895*)	Mar. 1, 1904
Storrs, Harry Asahel. Cons. Engr., 435 Century Bldg., Denver, Colo.	June 6, 1911
Stott, Henry Gordon. Supt. of Motive Power, Interborough Rap. Trans. Co., 600 West 59th St., New York City	July 1, 1908
Stowe, Harold Clair. Pres., H. C. Stowe Constr. Co., 221 Greenpoint Ave., Brooklyn, N. Y. (*Assoc. M., April 7, 1897*)	Jan. 4, 1910
Stowell, Charles Frederick. (Stowell & Cunningham), 51 State St., Albany, N. Y	April 4, 1888
Strachan, Joseph. 352 Putnam Ave., Brooklyn, N. Y. (*Assoc. M., May 4, 1892*)	May 4, 1898
Strachan, Robert Charles. Richmond Hill, N. Y	Aug. 31, 1909
Strahan, Charles Morton. Prof., Civ. Eng., Univ. of Georgia, Athens, Ga. (*Assoc. M., June 1, 1898*)	Nov. 1, 1910
Straub, Theodore Alfred. Vice-Pres. and Gen. Mgr., Fort Pitt Bridge Works, Pittsburgh, Pa	June 30, 1910
Street, Leonard Lee. Engr. and Contr., 95 Sawyer Ave., Dorchester, Mass	Oct. 5, 1909
Strehlow, Oscar Emil. Contr. Engr., James O. Heyworth, Harvester Bldg., Chicago, Ill. (*Assoc. M., Mar. 6, 1901*)	Sept. 6, 1904
Strickler, Gratz Brown. Pres., Southern Sand & Gravel Co., Inc., Fredericksburg, Va. (*Jun., Jan. 5, 1897; Assoc. M., Jan. 4, 1899*)	Nov. 1, 1904
STROBEL, CHARLES LOUIS. (*Vice-President*). Pres., Strobel Steel Constr. Co., 1744 Monadnock Blk., Chicago, Ill	Dec. 3, 1879
Strong, Carlton. Bellefield Dwellings, Pittsburgh, Pa	Jan. 4, 1910
Strong, Mason Romeyn. Cons. Engr. and Archt., 7 Wall St., New York City	Mar. 6, 1901
Strothman, Louis Edward. Mgr. and Chf. Engr., Pumping Engine Dept., Allis-Chalmers Co., Milwaukee, Wis	Dec. 5, 1911
Strouse, William Franklin. Asst. Engr., B. & O. R. R., Mt. Royal Station (Res., 400 Forest Rd., Roland Park), Baltimore, Md	Mar. 1, 1905
Stuart, Alfred Allen. Cons. Engr., Degnon Contr. Co.; Secy., Degnon Realty & Terml. Impvt. Co., 60 Wall St., New York City	Oct. 7, 1891
Stuart, Francis Lee. Chf. Engr., B. & O. R. R., Baltimore Md	May 3, 1899
Stuart, Joseph Thompson. 311 Arcade Bldg., Philadelphia, Pa	May 4, 1904
Stubbs, Linton Waddell. Superv. Engr., Galveston Causeway, Galveston, Tex	Oct. 3, 1888
Sturtevant, Carleton William. Supt., James Stewart & Co., Baldwinsville, N. Y	Oct. 2, 1901
Sublette, George Washington. Cons. Engr.; Const. Engr. and Contr., Care, Boll Hotel, Northfield, Minn	Oct. 1, 1902
Suhr, Otto Bruno. 808 Third St., Santa Monica, Cal	June 1, 1904
Sullivan, James Henry. Deputy Supt. of Streets, in Chg. of Highway Div., Room 44, City Hall, Boston, Mass	May 3, 1910
Sullivan, John G. Chf. Engr., C. P. Ry., Western Lines, Winnipeg, Man., Canada	Sept. 6, 1899
Sumner, Horace Augustus. Room 719, Selling Bldg., Portland, Ore	Oct. 4, 1899
Sumner, Robert Swan. 1607 Gilpin St., Denver, Colo. (*Assoc. M., June 3, 1903*)	Nov. 5, 1907
Sundstrom, Alfred Yngve. 4305 Baltimore Ave., Philadelphia, Pa. (*Assoc. M., June 6, 1906*)	May 31, 1910
Sundstrom, Carl Alfred. Surv. and Regulator, 8th Dist., Philadelphia, 4444 Main St., Manayunk, Philadelphia, Pa	Oct. 3, 1894
Supplee, Jesse. Mgr., Supplee Eng. Co., Cons., Designing and Const. Engrs., Scott Blk., Erie, Pa	June 3, 1903
Suter, Charles Russell. Brig.-Gen., U. S. A. (*Retired*), 287 Walnut St., Brookline, Mass	April 1, 1896
Sutermeister, Arnold Henry. Engr., Public Service Comm., Second Dist., Albany, N. Y	June 3, 1902
Sutton, Frank. Geographer, U. S. Geological Survey, Washington, D. C.	Oct. 3, 1906
Swaab, Solomon Mark. Care, Keystone State Constr. Co., Pennsylvania Bldg., Philadelphia, Pa. (*Jun., May 3, 1898; Assoc. M., Nov. 1, 1899*)	May 5, 1908
Swain, George Fillmore. Prof. of Civ. Eng., Harvard Univ.; Cons. Engr., Mass. R. R. Comm.; Member, Boston Transit Comm., Pierce Hall, Oxford St., Cambridge, Mass. (*Assoc., Sept. 5, 1883*)	Mar. 2, 1892
Swanker, John Edward. Engr., David Lupton's Sons Co., Allegheny Ave. and Tulip St., Philadelphia, Pa	May 4, 1904
Sweetser, Charles Herbert. Cons. Engr., Olympia, Wash	Sept. 5, 1911
Swendsen, George Lewis. Hydr. Engr., 522 Idaho Bldg., Boise, Idaho.	June 7, 1905
Swensson, Emil. Cons. and Constr. Engr., 925 Frick Bldg., Pittsburgh, Pa.	June 7, 1893
Swezey, Edwin Charles. Gen. Supt., Brooklyn Grade Crossing Comm., 44 Court St., Brooklyn, N. Y	Mar. 7, 1906

	Date of Membership
Swift, William Everett. Engr. with Ford, Bacon & Davis, Valier, Mont. *(Assoc. M., Sept. 2, 1903)*	June 30, 1910
Swinburne, George Way. 61 Whittlesey Ave., East Orange, N. J.	May 7, 1902
Sylvester, Frank McClellan. 1327 O. N. B. Bldg., Spokane, Wash.	Feb. 1, 1905
Sylvester, Ira Wallace. City Engr., Rapides Bank Bldg., Alexandria, La.	Nov. 7, 1906
Taber, George Aymar. Eng. in Chg., Constr. of Water Mains, Manhattan, Bronx and Richmond, Dept. of Water Supply, Gas and Electricity, 2032 Park Row Bldg., New York City. *(Jun., April 30, 1895; Assoc. M. June 7, 1899)*	Dec. 4, 1906
Tabor, Ernest Frederick. Project Engr., U. S. Reclamation Service, St. Ignatius, Mont.	May 1, 1907
Tainter, Frank Stone. (E. A. Stevens & Co.), 1 Newark St., Hoboken, N. J. *(Assoc. M., Jan. 3, 1900)*	Mar. 31, 1908
Talbot, Arthur Newell. Prof. of Municipal and San. Eng., and in Chg. of Theoretical and Applied Mechanics, Univ. of Illinois, Urbana, Ill.	April 4, 1888
Talbott, Harry Elstner. Dayton, Ohio	June 6, 1900
Talcott, Harry Randolph. Engr. of Surveys, B. & O. R. R., Central Office Bldg., Baltimore, Md.	Oct. 5, 1904
Tanabe, Sakuro. Prof. of Civ. Eng., Kyoto Imperial Univ., Kyoto, Japan.	Oct. 4, 1905
Tatum, Sledge. Geographer in Chg., Rocky Mountain Div., U. S. Geological Survey, Washington, D. C.	Jan. 4, 1910
Taussig, Hubert Primm. Cons. Engr., 14th and Locust Sts., St. Louis, Mo.	Oct. 3, 1894
Taylor, Benjamin Henry. Special Agt., Carnegie Steel Co. (Res., 323 Swissvale Ave., Edgewood Park), Pittsburgh, Pa.	May 4, 1904
Taylor, Charles Frederick. Pres., Maritime Dredging Co., 78 Broad St., New York City. *(Assoc. M., Sept. 4, 1895)*	April 4, 1905
Taylor, Edward Ballinger. Third Vice-Pres., Penn. Co. and P., C., C. & St. L. Ry., Room 901, Union Station, Pittsburgh, Pa.	Sept. 3, 1884
Taylor, Edwin Alexander. Supt. of Constr., Water Board, 186 Ford St., Portland, Ore. *(Assoc. M., June 7, 1905)*	June 2, 1908
Taylor, George McClellan. 2 Peters Pl., Red Bank, N. J.	Dec. 1, 1908
Taylor, Gorham Andrew. U. S. Junior Engr., U. S. Engr. Office, Duluth, Minn.	Feb. 1, 1910
Taylor, Granville Lewis. Asst. Chf. Engr., McClintic-Marshall Constr. Co., Pittsburgh, Pa. *(Assoc. M., Feb. 2, 1909)*	Sept. 5, 1911
Taylor, Harry. Lt.-Col., Corps of Engrs., U. S. A., Office, Chf. of Engrs., Washington, D. C.	Oct. 7, 1896
Taylor, Howard Flanders. Chf. Draftsman, Kansas City Terminal Ry., 800 Brighton Ave., Kansas City, Mo. *(Jun., Feb. 28, 1899; Assoc. M., June 6, 1906)*	April 6, 1909
Taylor, Hugh McGehee. Asst. Gen. Mgr., National Railways of Mexico, City of Mexico, Mexico	July 1, 1909
Taylor, James Townsend. Cons. Hydr. Engr., Honolulu, Hawaii	Jan. 3, 1894
Taylor, Lucian Arnold. Cons. Engr., 904 Tremont Bldg., Boston, Mass.	Nov. 4, 1891
Taylor, Samuel Alfred. Cons. Civ. and Min. Engr., 803 Lewis Blk., Pittsburgh, Pa.	Oct. 7, 1903
Taylor, Thomas Ulvan. Prof. of Civ. Eng., Univ. of Texas, Austin, Tex. *(Assoc., Jan. 31, 1893; Assoc. M., Oct. 2, 1895)*	Oct. 2, 1901
Taylor, William Gavin. Deputy Chf. Engr., Passaic Val. Sewerage Commrs., 820 Essex Bldg., Newark, N. J.	June 5, 1907
Tays, Eugene Augustus Hoffman. Min. Engr., San Blas, Distrito de Fuerte, Sinaloa, Mexico (*via* Nogales, Ariz.)	April 6, 1898
Teichman, Frank. Engr., U. S. Reclamation Service, El Paso, Tex.	Oct. 5, 1904
Teilman, Ingvart. Mgr. and Chf. Engr., Fresno & Consolidated Canal Companies, Fresno, Cal.	June 3, 1903
Temple, Edward Brinton. Asst. Chf. Engr., P. R. R., Broad St. Station, Philadelphia, Pa.	Oct. 2, 1907
Temple, William Henry Giles. Civ. and Hydr. Engr., 75 Westminster St., Providence, R. I.	Feb. 3, 1892
Tenney, Willis Robinson. Room 21, Municipal Bldg., Brooklyn, N. Y.	May 4, 1909
Terry, Hiram Everett. City Engr., Flint, Mich.	June 6, 1911
Terry, John Hermon. Secy. and Treas., Latta & Terry Constr. Co., 1319 Penna. Bldg., Philadelphia, Pa.	Oct. 2, 1907
Thacher, Edwin. Cons. Engr. (Concrete-Steel Eng. Co.), Park Row Bldg., New York City	Feb. 17, 1869
Thackray, George Edward. Structural Engr., Cambria Steel Co., Johnstown, Pa. *(Jun., Sept. 6, 1882)*	April 7, 1886
Thayer, Russell. United Gas Impvt. Co., Philadelphia, Pa.	Dec. 6, 1882
Thian, Prosper Eugene. Asst. Engr., N. P. Ry., Mandan, N. Dak.	Nov. 7, 1906
N. Thomas, Benjamin Franklin. U. S. Prin. Asst. Engr., 415 Custom House, Cincinnati, Ohio	April 6, 1887
Thomas, Chester Ashley. Res. Mgr., Yukon Gold Co., Dawson, Y. T., Canada	Nov. 8, 1909
Thomas, David Gorton. The Denver Union Water Co., Denver, Colo.	June 1, 1909

	Date of Membership
Thomas, John Charles. Vice-Pres., National Contract Co., New Cumberland, W. Va.	Feb. 28, 1911
Thomes, Edwin Howard. Asst. Engr., Bureau of Highways, Borough of Queens, New York City; Res., 161 Willett St., Jamaica, N. Y. *(Assoc. M., Dec. 6, 1899)*	Dec. 5, 1911
Thompson, Arthur Webster. Gen. Mgr., B. & O. R. R., Baltimore, Md. *(Assoc. M., June 4, 1902)*	April 5, 1910
Thompson, Benjamin. Cons. and Contr. Engr., 224 Am. National Bank, Tampa, Fla.	July 3, 1889
Thompson, Ellis Dunn. Cons. Engr., 804 Morris Bldg., Philadelphia, Pa.	Feb. 1, 1899
Thompson, Fred. Civ. Engr., U. S. N., Navy Dept., Washington, D. C.	Oct. 1, 1902
Thompson, Gaylord. Chf. Engr., Ohio Elec. Ry., Springfield, Ohio	April 2, 1890
Thompson, Henry Clark. Div. Engr., N. Y. C. & H. R. R. R., West 42d St. Ferry, New York City	Feb. 4, 1903
Thompson, Robert Andrew. Chf. Engr., California R. R. Comm., Room 7, Ferry Bldg., San Francisco, Cal. *(Jun., April 6, 1897; Assoc. M., Oct. 4, 1899)*	Jan. 3, 1911
Thompson, Samuel Clarence. Engr. of Highways, Borough of the Bronx, 177th St. and Third Ave., New York City	Feb. 6, 1889
Thompson, Sanford Eleazer. Cons. Engr., Newton Highlands, Mass. *(Assoc. M., April 1, 1896)*	May 1, 1906
Thompson, Wilford Ashford. Vice-Pres., East St. Louis Eng. Co., Cahokia Bldg., East St. Louis, Ill. *(Jun., Oct. 1, 1901; Assoc. M., Oct. 4, 1905)*	Nov. 30, 1909
Thompson, William Andrew. U. S. Asst. Engr., Upper Mississippi River Impvt., La Crosse, Wis.	Oct. 7, 1896
Thompson, William Love. Asst. Engr., Isthmian Canal Comm., Corozal, Canal Zone, Panama	June 6, 1911
Thomson, Ernest Burslem. U. S. Asst. Engr., U. S. Engr. Office, 321 Custom House, Portland, Ore. *(Assoc. M., June 5, 1901)*	May 31, 1904
Thomson, John. 253 Broadway, New York City	Mar. 2, 1887
Thomson, Reginald Heber. Chf. Engr., Seattle Port Comm. (Res., 955 Thirteenth Ave., North), Seattle, Wash.	Dec. 2, 1903
THOMSON, THOMAS KENNARD. *(Director)*. Cons. Engr., 50 Church St., New York City. *(Jun., Oct. 3, 1888; Assoc. M., June 3, 1891)*	Dec. 4, 1895
Thornley, Julian. The Ansonia, 74th St. and Broadway, New York City. *(Assoc. M., Jan. 2, 1901)*	Sept. 5, 1905
Thornton, Charles James. Care, Jamaica Govt. Ry., Kingston, Jamaica.	Sept. 6, 1910
Thurber, Clinton Draper. Civ. Engr., U. S. N., U. S. Naval Training Station, Naval Station, Ill. *(Assoc. M., Oct. 4, 1905)*	Feb. 28, 1911
Thurston, Eugene True, Jr. Designing and Const. Engr., 57 Post St., San Francisco, Cal. *(Assoc. M., Mar. 6, 1907)*	Feb. 28, 1911
Tibbals, George Attwater. Secy. and Treas., The Continental Iron Works, Brooklyn, N. Y. *(Jun., May 2, 1888)*	Mar. 4, 1896
Tibbals, Samuel Gaylord. The Continental Iron Works, Brooklyn, N. Y. *(Jun., May 2, 1888)*	May 5, 1897
Tighe, James Lawrence. Cons. Engr., 189 High St., Holyoke, Mass. *(Assoc. M., Oct. 5, 1898)*	May 31, 1904
Tillson, George William. Cons. Engr. to Borough Pres., Borough Hall (Res., 376 Parkside Ave.), Brooklyn, N. Y.	Oct. 7, 1896
Tilton, Benjamin Ellsworth. Engr., M. of W., New York State Rys., Rochester Lines, 267 State St., Rochester, N. Y.	June 6, 1911
Timonoff, Vsevolod Evguenievitch. Director, Statistical Dept., Ministry of Ways of Communications; Prof., Inst. of Ways of Communications; Member of the Technical Counsels, Ministry of Commerce and Industry, Ministry of Ways of Communications; Pres. of Hydrological Committee, Ministry of Agriculture, Shirokaia St., N 10, Tzarskoé Sélo, near St. Petersburg, Russia	May 3, 1893
Tingley, Richard Hoadley. 50 Church St., New York City	April 3, 1901
Tinker, George Henry. Bridge Engr., N. Y., C. & St. L. R. R., Hickox Bldg., Cleveland, Ohio	Aug. 31, 1909
Tinkham, Samuel Everett. Engr. of Constr., Bridge and Ferry Div., Public Works Dept., 60 City Hall, Boston, Mass.	Mar. 2, 1892
Tintorer y Giberga, Joseph. Claris 32, Barcelona, Spain	May 5, 1880
Tittmann, Otto Hilgard. U. S. Coast and Geodetic Survey, Washington, D. C.	June 4, 1902
Todd, Alexander Miller. U. S. Asst. Engr., P. O. Box 404, Vicksburg, Miss. *(Jun., Oct. 1, 1895; Assoc. M., Oct. 2, 1901)*	June 6, 1905
Todd, Frank Herbert. City Engr., Box 868, El Paso, Tex.	Feb. 6, 1889
Tollinger, Edward Chandler. U. S. Asst. Engr., P. O. Box 404, Vicksburg, Miss.	June 4, 1902
Tomlinson, Alfred Thomas. Dist. Engr., Grand Trunk Pacific, Districts C and D, N. T. C., Cochrane, Ont, Canada	Sept. 7, 1887
Tomlinson, Sam. N. High St., Singapore, Straits Settlements	April 6, 1892
Tompkins, Edward De Voe. Cons. and Const. Engr., 17 East 38th St., New York City. *(Jun., Feb. 2, 1897; Assoc. M., Dec. 3, 1902)*	May 1, 1906

	Date of Membership
Tompson, George Morris. Cons. Engr., Parker Rd., Wakefield, Mass.	May 2, 1888
Tone, Sumner La Rue. Second Vice-Pres., Pittsburgh Rys., Allegheny County Light Co., 435 Sixth Ave., Pittsburgh, Pa.	Dec. 4, 1901
Tonkin Thomas, Juan. Care, Bank of Chili, Santiago, Chili. (*Assoc. M., Mar. 7, 1900*)	Jan. 7, 1908
Tönnesen, Tobias. Gen. Representative and Engr-in-Chf., South West Africa Co., Ltd., Grootfontein, German S. W. Africa	May 1, 1901
Torrance, William Martin. Cons. Engr. (Torrance & Taylor), 39 Cortlandt St., New York City	July 1, 1909
Touceda, Enrique Augusto. Prof., Metallurgy, Rensselaer Polytechnic Inst.; Chemist and Metallurgist, Broadway, Cor. Thacher St., Albany, N. Y.	Jan. 3, 1900
Tower, James Wallace. Engr. for H. S. Ferguson, Room 1303, Fifth Ave. Bldg., New York City. (*Assoc. M., Oct. 2, 1901*)	Oct. 31, 1911
Tower, Morton Loudon. Asst. Engr., U. S. Engr. Office, 210 Federal Bldg., Eureka, Cal. (*Assoc. M., May 6, 1908*)	July 1, 1909
Towl, Forrest Milton. Pres., Southern Pipe Line Co., 206 Seneca St., Oil City, Pa. (Res., 794 Carroll St., Brooklyn, N. Y.)	Feb. 5, 1896
Towle, Stevenson. Cons. Engr., 17 West 90th St., New York City	Feb. 19, 1868
Townsend, Curtis McDonald. Col., Corps of Engrs., U. S. A., Post Office Bldg., Detroit, Mich.	Nov. 1, 1893
Trask, Frank Ellsworth. Cons. Civ. and Hydr. Engr., 616 Union Oil Bldg., Los Angeles, Cal. (*Assoc. M., June 5, 1895*)	Jan. 2, 1901
Treadwell, Lee. Vice-Pres. and Chf. Engr., Union Bridge & Constr. Co., 903 Sharp Bldg., Kansas City, Mo. (*Jun., Nov. 5, 1890; Assoc. M., Oct. 4, 1893*)	Dec. 2, 1896
Tresise, Francis John. Pres. and Mgr., Erie Contr. Co., 400 D. S. Morgan Bldg., Buffalo, N. Y.	June 6, 1911
Tretter, Gustav Adolph. Erection Mgr., Virginia Bridge & Iron Co., Roanoke, Va.	April 6, 1904
Tribus, Louis Lincoln. Cons. Engr. and Acting Commr. of Public Works, Borough of Richmond, New York City; Civ. and Hydr. Engr. (Tribus & Massa), 86 Warren St., New York City. (*Jun., April 4, 1888; Assoc. M., June 1, 1892*)	April 1, 1896
Triest, Wolfgang Gustav. Vice-Pres., The Snare & Triest Co., 143 Liberty St., New York City. (*Jun., Sept. 3, 1890; Assoc., Mar. 6, 1900*)	Jan. 31, 1905
Tripp, Oscar Holmes. Room 30, Court House, Rockland, Me. (*Assoc. M., Oct. 7, 1896*)	Sept. 5, 1905
Trocon, Albert Alexander. (The Midland Bridge Co., Freygang & Trocon, Proprs.), Kansas City, Mo.	May 1, 1895
Trotter, Alfred Williams. 141 Broadway, New York City. (*Jun., Sept. 5, 1883*)	Nov. 7, 1894
Trout, Charles Eliphalet. Asst. Engr., Dept. of Docks and Ferries, Pier A, North River, New York City. (*Jun., Oct. 31, 1899; Assoc. M., Jan. 8, 1902*)	Oct. 30, 1906
Trumbull, Morris Kinnard. Prin. Asst. Engr., Chi. & W. Indiana R. R., and Belt Ry. of Chicago, Room 67, Dearborn Station, Chicago, Ill.	April 5, 1910
Trundle, Horatio Hartley. Leesburg, Va. (*Assoc. M., June 7, 1899*)	Mar. 6, 1901
Tsuji, Taro. Engr., Imperial Govt. Rys., Hongo Yumicho Nichome 24, Tokyo, Japan. (*Jun., Oct. 8, 1891; Assoc. M., Oct. 4, 1899*)	Mar. 1, 1904
Tucker, Edward Austin. Structural Engr., 683 Atlantic Ave., Boston, Mass.	June 6, 1906
Tucker, Lester Waldo. With Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City	Dec. 4, 1901
Tucker, Ross Francis. Pres., Concrete Products Co., 35 West 32d St., Room 1103, New York City	Oct. 7, 1903
Tucker, William Conquest. 156 Fifth Ave., New York City. (*Jun., May 5, 1891; Assoc. M., Dec. 5, 1894*)	Jan. 3, 1905
Tuckey, Thomas Willard Townsend. Engr.-in-Chf., Tientsin-Pukow Ry., Nanking, China	June 3, 1903
Turner, Claude Allen Porter. Cons. Engr., 816 Phœnix Bldg., Minneapolis, Minn.	Mar. 6, 1901
Turner, Daniel Lawrence. Gen. Insp. of Stations, Public Service Comm. for the First Dist., 220 West 107th St., New York City. (*Assoc. M., Feb. 2, 1898*)	Jan. 3, 1905
Turner, Edmund Kimball. 53 State St., Boston, Mass.	Nov. 4, 1891
Turner, Nathaniel. 228 Calle de Hidalgo, Monterey, Mexico	Mar. 6, 1895
Turner, Orville Hickman Browning. Chf. Engr., St. Louis, Rocky Mt. & Pac. Ry., Raton, N. Mex.	Feb. 2, 1909
Tuska, Gustave Robitscher. Cons. Engr., 68 William St., New York City. (*Jun., Mar. 6, 1894; Assoc. M., Jan. 1, 1896*)	Nov. 2, 1900
Tutein-Nolthenius. Rudolph Peter Johann. No. 98 Nieuwe Plantage, Delft, The Netherlands	Dec. 6, 1899
Tuthill, Job. Bldg. Engr., Kansas City Terminal Ry., Kansas City, Mo. (*Jun., June 6, 1888*)	Oct. 4, 1893

	Date of Membership
Tuttle, Arthur Smith. Engr. in Chg., Div. of Public Impvts., Board of Estimate and Apportionment, 277 Broadway, New York City. (*Jun., Mar. 2, 1887; Assoc. M., May 2, 1894*)	Mar. 2, 1898
Tutwiler, Thomas Henry. Pres. and Gen. Mgr., The Memphis St. Ry., Memphis, Tenn	June 4, 1902
Tye, William Francis. Pres., Sterling Coal Co., 7 King St., East, Toronto, Ont., Canada	Sept. 1, 1897
Tyler, William Dowlin. Chf. Engr., Clinchfield Coal Corporation, Dante, Va	Nov. 30, 1909
Tyson, Anderson Harvey. 140th St. and East River, New York City	Oct. 2, 1889
Ubsdell, John Arnold, Jr. Gen. Supt., Great Lakes Eng. Works (Res., 294 West Grand Boulevard), Detroit, Mich	June 3, 1908
Uhler, William David. Second Asst. Engr., State Roads Comm., Care, Johns Hopkins Univ., Baltimore, Md. (*Assoc. M., May 6, 1908*)	Mar. 1, 1910
Uhlig, Carl. Asst. Engr., Board of State Harbor Commrs., Ferry Bldg., San Francisco, Cal	Oct. 7, 1903
Ulrich, John Clarence. Civ. and Hydr. Engr., Denver, Colo	Mar. 4, 1908
Upham, Charles Clifton. Vice-Pres. and Gen. Mgr., New York Steam Co., 140 Cedar St., New York City	April 7, 1897
Vail, Charles Davis. (Vail, Walbron & Read), 1220 First National Bank Bldg., Denver, Colo. (*Assoc. M., June 6, 1900*)	Aug. 31, 1909
Value, Beverly Reid. Empire Eng. Corporation, 60 Wall St., New York City	Jan. 2, 1901
Van Alstyne, Henry Arthur. 149 Echo Ave., New Rochelle, N. Y. (*Assoc. M., June 6, 1900*)	Dec. 3, 1907
Van Buren, John D. New Brighton, Borough of Richmond, N. Y	May 20, 1868
Van Buren, Robert. 58 West Ave., Norwalk, Conn	June 17, 1868
Van Cleve, Aaron Howell. 220 West 57th St., New York City. (*Jun., May 31, 1892; Assoc. M., Dec. 5, 1894*)	Nov. 1, 1904
Vandevanter, Charles Oscar. Cons. Engr., Leesburg, Va	Sept. 2, 1896
van Diest, Edmond Cornelis. Cons. Engr., P. O. Box 82, Colorado Springs, Colo	Sept. 5, 1911
Van Frank, Phillip Riley, Jr. Care, U. S. Engr. Office, Little Rock, Ark	Aug. 31, 1909
Van Hoesen, Edmund French. Expert on Railroad Crossings, Barge Canal, Albany, N. Y	July 1, 1891
Van Horne, John Garret. 165 Broadway, Room 2611, New York City	Feb. 4, 1880
Van Keuren, Charles Augustus. 21 Monticello Ave., Jersey City, N. J	May 3, 1905
Van Loan, Seth Morton. First Asst. to Chf., Bureau of Water, Room 790, City Hall, Philadelphia, Pa. (*Jun., Dec. 28, 1900; Assoc. M., Oct. 7, 1903*)	May 2, 1911
Van Norden, Ernest Maitland. Civ. Engr., New York Edison Co., 55 Duane St., New York City (Res., 1065 Sterling Pl., Brooklyn, N. Y.). (*Assoc. M., May 6, 1903*)	Oct. 2, 1906
Van Norden, Rudolph Warner. Cons. Engr., 517 Nevada Bank Bldg., San Francisco, Cal	July 1, 1909
Van Orden, Charles Hopkins. Catskill, N. Y	June 1, 1898
Van Ornum, John Lane. Prof. of Civ. Eng., Washington Univ., St. Louis, Mo. (*Assoc. M., Oct. 3, 1894*)	Oct. 4, 1899
Van Sant, Robert Lawrence. Contr. Engr., 421 Olive St., St. Louis, Mo.	Sept. 3, 1884
Van Vleck, John. 100 Broadway, New York City	May 3, 1905
Van Winkle, Edgar Beach. 115 East 70th St., New York City	Dec. 2, 1868
Van Winkle, Edward. Cons. Patent Engr., The West St. Bldg., New York City	Nov. 30, 1909
Vauclain, Samuel Matthews. Vice-Pres., Baldwin Locomotive Works, 500 North Broad St., Philadelphia, Pa	Dec. 5, 1911
Vaughan, Charles Herbert. Second Vice-Pres. and Chf. Engr., Penn Bridge Co., 3409 Fifth Ave., Beaver Falls, Pa	May 2, 1906
Vaughan, George Washington. Engr., M. of W., N. Y. C. & H. R. R. R., Grand Central Palace, New York City. (*Jun., Mar. 3, 1886*)	Nov. 4, 1896
Vaughan, Louis Bertrand. 172 Downs St., Kingston, N. Y	Jan. 31, 1911
Vaughn, George Washington. Leavenworth, Kans	June 3, 1891
Vehrenkamp, Henry William. Chf. Engr., Ferro Concrete Constr. Co., 3113 Murdock Ave., Cincinnati, Ohio. (*Assoc. M., June 5, 1907*)	June 30, 1911
Venable, William Mayo. Engr., Blaw Collapsible Steel Centering Co., Westinghouse Bldg., Pittsburgh, Pa. (*Assoc. M., Sept. 4, 1901*)	Oct. 1, 1907
Vent, Frederick Goodman. Asst. Engr., C., B. & Q. R. R., 226 West Adams St., Chicago, Ill	May 3, 1910
Verrill, George Elliot. U. S. Asst. Engr., 407 First National Bank Bldg., New Haven, Conn	Mar. 2, 1904

	Date of Membership
Veuve, Erle Leroy. Cons. Engr., 651 Pacific Electric Bldg., Los Angeles, Cal. (*Jun., Sept. 3, 1901*)	Feb. 2, 1909
Vielé, Maurice Augustus. 49 Wall St., New York City. (*Jun., Feb. 4, 1891; Assoc. M., Sept. 7, 1892*)	Oct. 6, 1897
Vincent, Edward Franklin. Asst. Chf. Engr., Colo. & South. Ry., 805 Cooper Blk., Denver, Colo	Aug. 31, 1909
Vincent, Edwin Derickson. Asst. Chf. Engr., Bureau of Harbor Impvt., City Hall, Los Angeles, Cal	May 4, 1909
Vincent, James Irving. Asst. Engr., The Scherzer Rolling Lift Bridge Co. of Chicago, 220 Broadway, New York City	June 30, 1910
Vogleson, John Albert. 1317 Spruce St., Philadelphia, Pa. (*Assoc. M., Jan. 2, 1901*)	Mar. 31, 1908
von Emperger, Fritz Edler. K. K. Oberbaurat; Rat im K. K. Patentamt; Herausgeber von *Beton und Eisen*, Vienna IV, Austria	Feb. 5, 1908
von Geldern, Otto. Cons. Engr., 865 Pacific Bldg., San Francisco, Cal.	May 4, 1892
von Leer, Isaac Wayne. Civ. and Min. Engr., Care, A. W. von Leer, 403 Franklin Bank Bldg., Philadelphia, Pa	May 3, 1899
von Piontkowski, Edgar Stanislaus. 15 Calle Nebraska, Manila, Philippine Islands	Jan. 3, 1911
von Schon, Hans August Evald Conrad. Cons. Engr., 603 Wayne County Bank Bldg., Detroit, Mich	Sept. 2, 1902
Voorhees, Theodore, Vice-Pres., P. & R. Ry., Reading Terminal, Philadelphia, Pa.	May 6, 1885
Vorce, Clarence Browning. Engr. of Constr., British Columbia Elec. Ry., Ltd., Vancouver, B. C., Canada. (*Jun., April 30, 1895; Assoc. M., Oct. 7, 1896*)	May 2, 1900
Vose, Richard Hampton. Colima, Colima, Mexico	Oct. 7, 1908
Vredenburgh, Watson, Jr. Cons. and Inspecting Engr. (Hildreth & Co.), 17 Battery Pl., New York City. (*Assoc. M., Mar. 6, 1901*)	Mar. 1, 1910
Waddell, Charles Edward. 78 Patton Ave., Asheville (Res., Biltmore), N. C.	Mar. 1, 1910
N. Waddell, John Alexander Low. Cons. Engr. (Waddell & Harrington), 1012 Baltimore Ave., Kansas City, Mo	Oct. 5, 1881
Waddell, Montgomery. Cons. Engr., 1 West 101st St., New York City. (*Jun., Sept. 1, 1886*)	Sept. 2, 1896
Waddell, Robert William. 3212 Central St., Kansas City, Mo	Sept. 4, 1901
Wadsworth, George Reed. Asst. to the Pres., The Peerless Motor Car Co., Cleveland, Ohio. (*Assoc. M., Nov. 7, 1906*)	Nov. 8, 1909
Wadsworth, Henry Hayes. Room 410, Custom House, San Francisco, Cal	Oct. 2, 1901
Wadsworth, Joel Edward. Res. Engr., Am. Bridge Co., 30 Church St., New York City. (*Jun., Dec. 5, 1893; Assoc. M., May 5, 1897*)	June 6, 1905
Wagner, Bernard Matthew. Engr. in Chg., Watershed Div., Dept. of Water Supply, Gas and Electricity, Rockville Center, N. Y. (*Assoc. M., May 3, 1899*)	Dec. 1, 1903
Wagner, Fred J. Chf. Engr., Scott Bros., P. O. Box 403, Rome, N. Y. (*Assoc. M., April 4, 1906*)	Sept. 6, 1910
Wagner, Harry Edward. Res. Engr., D., L. & W. R. R., Andover, N. J. (*Assoc. M., Nov. 6, 1907*)	June 6, 1911
Wagner, Joseph Christian. Surv. and Regulator, 9th Survey Dist., Dept. of Public Works, Philadelphia National Bank Bldg., Germantown (Res., 1539 North 12th St.), Philadelphia, Pa. (*Assoc. M., June 7, 1899*)	June 5, 1906
Wagner, Samuel Tobias. Asst. Engr., P. & R. Ry., Huntingdon St. Station, Philadelphia, Pa	Feb. 2, 1887
Wagoner, Luther. Cons. Engr., 910 Pacific Bldg., San Francisco, Cal.	May 2, 1906
Wait, John Cassan. Attorney at Law, Eng. Jurisprudence, 38 Park Row, New York City	Feb. 3, 1892
Waite, Guy Bennett. Mgr., Standard Concrete Steel Co., 31st-32d Sts., East River, New York City. (*Assoc. M., May 2, 1894*)	Nov. 5, 1907
Waldo, Mark Albigence. Care, The Dominion Phosphate Co., Bartow, Fla	May 2, 1900
Waldron, Samuel Payson. Care, Am. Bridge Co., 30 Church St., New York City. (*Assoc. M., Jan. 7, 1903*)	May 4, 1909
Walker, Clement Isaac. Chf. Engr., Empire City Subway Co. (Ltd.), 426 West 58th St., New York City. (*Assoc. M., April 1, 1891*)	May 3, 1904
Walker, Elton David. Prof. of Hydr. and San. Eng., The Pennsylvania State Coll., and Cons. Engr., State College, Pa. (*Jun., Oct. 4, 1892; Assoc. M., June 1, 1898*)	Sept. 5, 1900
Walker, Emery Lafayette. Eastern Mgr., Pacific Coast Condensed Milk Co., Berlin, Wis	May 3, 1910
Walker, Frank Hiram. Cons. and Superv. Engr., Water-Works, Sewerage and Irrig., Ashland, Ore	Aug. 31, 1909

		Date of Membership
	Walker, James Wilson Grimes. Civ. Engr., U. S. N.; Public Works Officer, U. S. Naval Station, Narragansett Bay, Newport, R. I.	Oct. 5, 1904
	Walker, Jesse Wager. (Pittsburgh Constr. Co.), Diamond National Bank Bldg., Pittsburgh, Pa.	May 7, 1884
	Walker, John Simpson. U. S. Asst. Engr., Nashville, Tenn.	Jan. 5, 1881
	Walker, Meriwether Lewis. Maj., Corps of Engrs., U. S. A., Fort Leavenworth, Kans.	Feb. 2, 1909
	Walker, William Thomas. Constr. Engr., H. M. Byllesby & Co., 206 South La Salle St., Chicago, Ill.	June 30, 1911
R.	Wall, Edward Everett. Water Commr., 312 City Hall, St. Louis, Mo.	Feb. 1, 1905
	Wallace, Harold Ulmer. Cons. Engr., Marquette Bldg., Chicago, Ill.	Dec. 7, 1904
R.	WALLACE, JOHN FINDLEY. (*Past-President*). Pres., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City	June 2, 1886
	Wallace, John Herbert. Cons. Engr., 2414 Gough St., San Francisco, Cal.	Jan. 2, 1890
	Wallace, Joseph Harrison. 5 Beekman St., New York City (Res., 7 Webster Terrace, New Rochelle, N. Y.). (*Jun., Dec. 1, 1896; Assoc. M., Dec. 1, 1897*)	Nov. 6, 1901
	Walmsley, Walter Newbold. Care, São Paulo Tramway, Light & Power Co., Ltd., São Paulo, Brazil	Dec. 1, 1908
	Walsh, George Scherzer. Sambigiegno Mines, Medellin, Antioquia, Colombia. (*Jun., Feb. 2, 1897; Assoc. M., May 1, 1901*)	Mar. 31, 1908
	Walter, Raymond F. Superv. Engr., U. S. Reclamation Service, 519 Commonwealth Bldg., Denver, Colo.	Oct. 5, 1909
	Waltman, William DeWitt. Res. Engr., The Costilla Estates Development Co., San Acacio, Colo. (*Assoc. M., Dec. 1, 1908*)	June 6, 1911
	Ward, Charles Dod. 702 St. Nicholas Ave., New York City	Mar. 3, 1869
	Ward, Thomas Monroe. Care, Mrs. E. A. Lewis, Fort Missoula, Missoula, Mont.	Mar. 7, 1906
	Wardle, Edward Beaumont. Engr. for Geo. F. Hardy, 309 Broadway, Room 608, New York City. (*Assoc. M., Dec. 4, 1907*)	May 31, 1910
	Ware, John. Asst. Treas., Portneuf-Marsh Val. Irrig. Co., Downey, Idaho. (*Assoc. M., July 9, 1906*)	April 4, 1911
	Warner, Edwin Hall. 329 San Fernando Bldg., Los Angeles, Cal. (*Assoc. M., May 6, 1891*)	Oct. 4, 1893
	Warner, Frank Charles. U. S. Asst. Engr., Delaware City, Del.	Dec. 6, 1905
	Warren, William Henry. Challis Prof. of Eng., Univ. of Sydney, Sydney, New South Wales, Australia	Feb. 5, 1890
	Warrington, Harry Esmond. 1486 West 8th St., Riverside, Cal. (*Assoc. M., April 6, 1898*)	Mar. 5, 1907
	Washburn, Delos Cuyler. Elk River, Minn.	May 3, 1910
	Washburn, Frank Sherman. Engr., Stahlman Bldg., Nashville, Tenn.	Nov. 7, 1888
	Wason, Leonard Chase. Pres. and Engr., Aberthaw Constr. Co., 8 Beacon St., Boston, Mass. (*Assoc. M., April 3, 1901*)	April 1, 1903
	Waterhouse, John. 237 West 142d St., New York City	Oct. 4, 1899
	Wathen, Benjamin Southern. Chf. Engr., Tex. & Pac. Ry., Dallas, Tex.	Nov. 2, 1892
	Watkins, Frederick William. Div. Engr., Jerome Park Reservoir Div., Dept. of Water Supply, Gas and Electricity, New York City (Res., 45 Rockledge Ave., White Plains, N. Y.)	Oct. 3, 1883
	Watkins, Richard. "Hawarden," Nelson St., Woollahra, near Sidney, New South Wales, Australia	Dec. 3, 1890
	Watson, Irvine. Engr., U. S. Reclamation Service, Sunnyside, Wash. (*Assoc. M., June 3, 1903*)	Mar. 3, 1908
	Watson, Wilbur Jay. 1328 Citizens Bldg., Cleveland, Ohio. (*Jun., Oct. 4, 1898; Assoc. M., Jan. 2, 1901*)	Jan. 3, 1905
	Watson, William. Secy., Am. Acad. of Arts and Sciences, 107 Marlborough St., Boston, Mass. (*Assoc., Mar. 1, 1882*)	Sept. 2, 1891
	Watt, David Alexander. U. S. Engr. Office, 510 Lonja, Havana, Cuba.	Feb. 6, 1901
	Watt, John Marshall Gilkison. Asst. Div. Engr., Corozal, Canal Zone, Panama	Feb. 5, 1902
	Waugh, William Hammond. Div. Engr., Bureau of Public Works, Manila, Philippine Islands. (*Jun., Oct. 1, 1901; Assoc. M., June 5, 1907*)	Sept. 5, 1911
	Wauters, Carlos. Prof., National Univ. of Buenos Aires.; Civ. and Const. Engr., Avenida de Mayo 878, Buenos Aires, Argentine Republic	Oct. 5, 1909
	Webb, De Witt Clinton. Civ. Engr., U. S. N., Navy Yard, Boston, Mass.	Sept. 6, 1905
	Webb, George Herbert. Chf. Engr., Mich. Cent. R. R., Detroit, Mich.	Feb. 1, 1893
	Webb, Walter Loring. Chf. Civ. Engr., Day & Zimmermann, 608 Chestnut St., Philadelphia, Pa. (*Assoc. M., May 4, 1892*)	May 3, 1904
	Weber, Alexander Hamilton. U. S. Asst. Engr.; Secy., U. S. Board of Engrs. for Rivers and Harbors, Southern Bldg., Washington, D. C.	Oct. 3, 1900
	Webster, Albert Lowry. Cons. Engr., 82 Wall St., New York City. (*Jun., Sept. 6, 1882; Assoc. M., June 3, 1891*)	April 6, 1909
	Webster, Charles Edward. Cons. Engr., South Bethlehem, Pa.	Oct. 4, 1899
	Webster, George Smedley. Chf. Engr. and Surv., Bureau of Surveys, City Hall, Philadelphia, Pa. (*Assoc. M., Sept. 7, 1892*)	Oct. 4, 1893

	Date of Membership
Webster, William Richardson. Cons. and Insp. Engr., 411 Walnut St., Philadelphia, Pa	April 5, 1899
Weedin, Kirby Calhoun. Constr. Supt., J. G. White & Co., Inc., 43 Exchange Pl., New York City	April 5, 1910
Weeks, William Charles. Contr. Engr., 14 Burns Blk., Vancouver, B. C., Canada	Oct. 2, 1907
Wegmann, Edward. Cons. Engr., Dept. of Water Supply, Gas and Electricity, 13 Park Row, Room 2520, New York City	Mar. 7, 1888
Weidman, William Roe. 369 Williams Ave., Portland, Ore	Feb. 1, 1910
Weiskopf, Samuel C. Cons. Engr., 68 William St., New York City. *(Jun., May 7, 1884)*	Dec. 5, 1888
Wells, Charles Edwin. Div. Engr., Board of Water Supply, City of New York, 215 Kimball Ave., Yonkers, N. Y	June 1, 1892
Wells, George Miller. Office Engr., Atlantic Div., Gatun, Canal Zone, Panama. *(Assoc. M., Oct. 3, 1906)*	Jan. 3, 1911
Wells, James Hollis. Civ. Engr. and Archt., 32 Nassau St., New York City	Feb. 5, 1901
Wells, Lawrence William. Asst. to Gen. Mgr. and Chf. Engr., Tex. Midland R. R., Terrell, Tex	Dec. 5, 1906
Wendt, Edwin Frederick. Asst. Engr., Pitts. & Lake Erie R. R., Terminal Bldg., Pittsburgh, Pa	Oct. 7, 1903
Wentworth, Charles Austin. Cons. Engr., 703 Empire Bldg., Philadelphia, Pa. *(Assoc. M., Oct. 7, 1903)*	Jan. 2, 1912
Wentworth, Charles Chancellor. Prin. Asst. Engr., N. & W. Ry., Roanoke, Va	April 4, 1888
Wenzell, Andrew Jackson. Cons. Engr., 107 West Hancock, Detroit, Mich	Oct. 3, 1906
West, Charles Hunter. Cons. Engr.; Member, Mississippi River Comm., Greenville, Miss	Oct. 1, 1902
Westcott, Frank Thomas. North Attleborough, Mass	Jan. 3, 1911
Westinghouse, George. Pittsburgh, Pa	Jan. 7, 1891
Weston, Charles Valentine. 915 First National Bank Bldg., San Francisco, Cal	Sept. 5, 1900
Weston, Edmund Brownell. Cons. Engr.; Pres., Jewell Export Filter Co., 86 Weybosset St., Providence, R. I	Dec. 6, 1882
Weston, George. Asst. Chf. Engr., Board of Superv. Engrs., Chicago Traction, 181 La Salle St., Chicago, Ill	June 5, 1907
Weston, Robert Spurr. Cons. San. Engr., 14 Beacon St., Boston, Mass. *(Assoc. M., Feb. 5, 1902)*	Oct. 31, 1911
Wetherbee, George Albert. Inglewood, Cal	April 5, 1893
Wetherill, William Chattin. Cons. Engr., The Empire Zinc Co., 703 Symes Bldg., Denver, Colo	Dec. 1, 1886
Weymouth, Aubrey. Chf. Engr., Post & McCord, Inc., 44 East 23d St., New York City (Res., 130 Central Ave., Flushing, N. Y.)	May 2, 1911
Weymouth, Frank Elwin. Superv. Engr., U. S. Reclamation Service, Boise, Idaho. *(Assoc. M., Sept. 4, 1901)*	Feb. 5, 1907
Wharf, Allison James. Asst. Supt., U. P. R. R., 5068 Sunnyside Ave., Chicago, Ill	April 4, 1911
Wheeler, Bertrand Thorp. Engr. of Constr., N. Y., N. H. & H. R. R. and B. & M. R. R.; Chf. Engr., The Boston Terminal Co., 440 South Station, Boston, Mass	June 30, 1910
Wheeler, Daniel Merrick. Railroad Insp., Mass. R. R. Comm., 230 Forest Park Ave., Springfield, Mass	Mar. 6, 1901
Wheeler, Ebenezer Smith. U. S. Asst. Engr., Detroit, Mich	Nov. 7, 1883
Wheeler, Edgar True. 1038 West 20th St., Los Angeles, Cal	Dec. 7, 1904
Wheeler, Harry Roberts. Engr.-in-Chg. and Secy., Henry Steers, Inc., 17 Battery Pl., New York City. *(Jun., April 4, 1888; Assoc. M., May 4, 1892)*	Mar. 1, 1910
Wheeler, Levi Lockwood. Asst. U. S. Engr., Sterling, Ill	June 4, 1884
Wheeler, William. Cons. Engr., 14 Beacon St., Boston, Mass	Oct. 4, 1893
Wheelock, De Forest Augustus. Civ. and San. Engr., City Bldg., Warren, Pa. *(Assoc. M., Feb. 3, 1897)*	April 30, 1907
Whildin, William Gwilym. Supt., Inside Div., Lehigh Coal & Nav. Co., Lansford, Pa	May 6, 1908
Whinery, Samuel. Cons. Engr., 95 Liberty St., New York City. *(Jun., April 1, 1874)*	May 4, 1881
Whipple, George Chandler. Prof. of San. Eng., Harvard Univ.; Cons. Engr., 103 Park Ave., New York City. *(Assoc. M., Sept. 6, 1899)*	Oct. 6, 1908
Whistler, John T. Cons. Engr., U. S. National Bank Bldg., Portland, Ore. *(Assoc. M., Jan. 2, 1901)*	Oct. 7, 1903
White, Henry Fisher. 5322 Kimbark Ave., Chicago, Ill	Jan. 2, 1890
White, James Gilbert. Pres., J. G. White & Co., Inc., 43 Exchange Pl., New York City	Mar. 2, 1904
White, Timothy Sidney. Vice-Pres. and Cons. Engr., Penn Bridge Co., Beaver Falls, Pa	April 3, 1889

		Date of Membership
	White, Willard Olney. Cons. Civ. and Min. Engr., First National Bank Bldg., Uniontown, Pa. *(Assoc. M., April 3, 1907)*	Jan. 3, 1911
	White, William MacIntire. Care, Am. Bridge Co., 30 Church St., New York City. *(Assoc. M., Jan. 2, 1901)*	Mar. 2, 1909
	Whited, Willis. Bridge Engr., State Highway Dept., Harrisburg, Pa. *(Assoc. M., Oct. 2, 1901)*	Nov. 1, 1910
	Whitfield, James Edward. Min. Engr., 406 Locust St., Philadelphia, Pa.	Mar. 2, 1904
	Whitford, Reid. Secy. and Engr. of the San. and Drainage Comm. for Charleston County (Res., 174 Rutledge Ave.), Charleston, S. C.	Dec. 2, 1896
	Whitman, Ezra Bailey. Water Engr. and Pres., Water Board, City Hall, Baltimore, Md. *(Jun., Feb. 3, 1903; Assoc. M., Feb. 7, 1906)*	June 30, 1910
	Whitmer, David Heikes. Asst. Supt., Am. Pipe & Constr. Co., 112 North Broad St., Philadelphia, Pa.	May 6, 1903
	Whitney, Frank Ormond. Chf. Engr., Street Laying-Out Dept., 100 Summer St., Boston, Mass. *(Jun., May 3, 1876)*	Jan. 5, 1887
	Whitney, Thomas Bryan, Jr. Engr. of Design, Hudson & Manhattan R. R., 30 Church St., New York City. *(Jun., Sept. 6, 1898; Assoc. M., Feb. 6, 1907)*	April 5, 1910
	WHITTEMORE, DON JUAN. *(Past-President)*. Cons. Engr., C., M. & St. P. Ry., 222 Biddle St., Milwaukee, Wis. *(Hon. M., Jan. 6, 1911)*	July 10, 1872
	Whittemore, Walter Frank. 1 Newark St., Hoboken, N. J. *(Jun., Mar. 6, 1889; Assoc. M., April 6, 1892)*	Oct. 31, 1905
	Whittier, Thomas Tupper. Engr. for George F. Hardy, 309 Broadway, New York City	May 31, 1910
	Wickes, Edward Dana. Cons. Engr., Brunson Bldg., Columbus, Ohio. *(Assoc. M., Dec. 3, 1902)*	Oct. 2, 1906
	Wiest, Julius Christian. Contr.; Gen. Mgr., Nicaragua R. R. and Steamer Line, Managua, Nicaragua	Feb. 5, 1902
	Wilcox, Frank. Engr. of The T. A. Gillespie Co., 800 Westinghouse Bldg., Pittsburgh, Pa.	Oct. 7, 1903
	Wiley, Andrew Jackson. Cons. Hydr. Engr., Boise, Idaho	Dec. 5, 1894
	Wiley, William Halsted. Scientific Publisher, 43 East 19th St., New York City	Feb. 17, 1869
	Wilgus, Herbert Sedgwick. Engr., M. of W., Pitts., Shawmut & North. R. R., Angelica, N. Y. *(Jun., Oct. 1, 1901; Assoc., Nov. 3, 1903; Assoc M., Nov. 1, 1904)*	June 6, 1911
R.	Wilgus, William John. 165 Broadway, New York City	April 1, 1896
	Wilkerson, Thomas Jefferson. Engr., Div. of Bridges, Bureau of Constr., Dept. of Public Works, City Hall, Pittsburgh, Pa. *(Jun., April 3, 1894; Assoc. M., Jan. 5, 1898)*	Sept. 6, 1910
	Wilkes, James Knapp. Chf. Engr., Board of Public Works, New Rochelle, N. Y. *(Assoc. M., June 3, 1891)*	April 3, 1906
	Wilkins, William Glyde. Engr. and Archt. (The W. G. Wilkins Co.), Westinghouse Bldg., Pittsburgh, Pa.	Dec. 4, 1889
	Wilkinson, Thomas Lee. Cons. Mech. Engr., 407 Boston Bldg., Denver, Colo.	Feb. 5, 1908
	Williams, Charles Page. Project Engr., U. S. Reclamation Service, Powell, Wyo. *(Assoc. M., Oct. 2, 1901)*	Nov. 1, 1904
	Williams, Chauncey Grant. 3 Montague Terrace, Brooklyn, N. Y. *(Assoc. M., Feb. 6, 1895)*	Oct. 7, 1903
	Williams, Cyrus John Richard. Engr., Lyttelton Harbour Board, Christchurch, New Zealand	Feb. 6, 1901
	Williams, David. Div. Engr., B. & M. R. R., St. Johnsbury, Vt.	May 4, 1898
	Williams, Edward Gilbert. Constr. Mgr., J. G. White & Co., Inc., 43 Exchange Pl., New York City	Feb. 3, 1897
	Williams, Frederick Charles. Cons. Engr., 426 Cuyahoga Bldg., Cleveland, Ohio	May 2, 1911
	Williams, Friend Pitts. Res. Engr., N. Y. State Barge Canal, Mechanicsville, N. Y.	July 1, 1909
N.	Williams, Gardner Stewart. Cons. Engr., 303 South State St., Ann Arbor, Mich. *(Assoc. M., Oct. 2, 1895)*	Dec. 6, 1899
	Williams, John Norman Spencer. Supt., Kahului R. R., Kahului, Maui, Hawaii	April 5, 1910
	Williams, Samuel Daugherty, Jr. Care, Mich. Cent. R. R., 489 Fort St., West, Detroit, Mich. *(Assoc. M., Dec. 2, 1903)*	Jan. 7, 1908
	Williams, William Fish. City Engr., S. E. Cor. Court and Orchard Sts., New Bedford, Mass.	April 4, 1906
	Williamson, Charles Sumner. Western Mgr., Mead-Morrison Mfg. Co., 746 Monadnock Blk., Chicago, Ill. *(Assoc. M., Feb. 7, 1906)*	Oct. 31, 1911
	Williamson, Francis Stuart. Cons. Engr., 84 William St., New York City.	Sept. 7, 1887
	Williamson, Frank Robert. Asst. Engr., San. Dist. of Chicago, 1500 Am. Trust Bldg., Chicago, Ill.	Nov. 7, 1906
	Williamson, Sydney Bacon. Div. Engr., Pacific Div., Panama Canal, Corozal, Canal Zone, Panama. *(Assoc. M., Jan. 3, 1894)*	Dec. 2, 1896
	Willis, Paul. Secy. and Engr., Kenwood Bridge Co., 4857 Madison Ave., Chicago, Ill.	Oct. 2, 1901

	Date of Membership
Willoughby, Julius Edgar. Engr. of Constr., L. & N. R. R.; Chf. Engr. of Constr., Lexington & East. Ry., Louisville, Ky	June 1, 1909
Wilson, Charles Alfred. Ry. Expert, 529 Burns Ave., Station R, Cincinnati, Ohio	April 1, 1891
Wilson, Charles Beatty. Supt., Foster-Creighton-Gould Co., Caryville, Fla	Dec. 2, 1903
Wilson, Charles Coker. 1302 Main St., Columbia, S. C	Dec. 4, 1907
Wilson, Charles William Schrage. Gen. Contr. (Wilson & English Constr. Co.), New York City (Res., New Rochelle, N. Y.). *(Jun., April 5, 1892; Assoc. M., Jan. 3, 1900)*	June 6, 1905
Wilson, Elliott Hinckley. Civ. and Min. Engr., Box 224, Butte, Mont.	Feb. 1, 1888
Wilson, Everett Broomall. Pres., The Am. Bureau of Inspection and Tests, 1427 Monadnock Blk., Chicago, Ill. *(Assoc. M., Mar. 4, 1903)*.	Dec. 6, 1904
Wilson, George Leverett. Engr., M. of W., Twin City Rap. Trans. Co., Minneapolis, Minn	Feb. 5, 1890
Wilson, Henry Felix, Jr. 1009 South 13th St., Birmingham, Ala. *(Assoc. M., April 2, 1902)*	May 2, 1905
Wilson, Henry William. 1060 Drexel Bldg., Philadelphia, Pa	Sept. 6, 1876
Wilson, Herbert Michael. Engr. in Chg., U. S. Bureau of Mines, Pittsburgh, Pa. *(Jun., Sept. 5, 1883)*	Jan. 2, 1890
Wilson, Percy Hartshorne. Secy., Assoc. of Am. Portland Cement Mfrs., 1526 Land Title Bldg., Philadelphia, Pa. *(Jun., Jan. 2, 1900; Assoc. M., Feb. 5, 1902)*	Oct. 5, 1909
Wilson, William Edward. Secy., Am. Section, International Waterways Comm., 328 Federal Bldg., Buffalo, N. Y. *(Jun., Jan. 6, 1903; Assoc. M., June 7, 1905)*	June 30, 1910
Wilson, Winter Lincoln. Prof. of Railroad Eng., Lehigh Univ., South Bethlehem (Res., 56 Church St., Bethlehem), Pa	May 1, 1901
Wiltsee, William Pharo. Asst. Engr., N. & W. R. R., Roanoke, Va. *(Assoc. M., Oct. 7, 1903)*	Mar. 1, 1910
Wimmer, Sebastian. R. F. D. No. 1, Albany, Stearns Co., Minn	Mar. 2, 1881
Windsor, Philip Brundage. Care, The Development Co. of Cuba, Ceballos, Cuba	July 1, 1909
Wing, Charles Benjamin. Prof. of Structural Eng., Stanford Univ., 345 Lincoln Ave., Palo Alto, Cal. *(Assoc. M., Nov. 4, 1896)*	Nov. 2, 1908
Wingfield, Nisbet. Cons. Engr. for Hydr., Sewerage, and Municipal Lighting Plants, Augusta, Ga	May 1, 1895
Winslow, Benjamin Emanuel. Structural Engr., 2540 North Sacramento Ave., Chicago, Ill	Oct. 2, 1907
Winsor, Frank Edward. Dept. Engr., Board of Water Supply, City of New York, Realty Bldg. (Res., 137 South Broadway), White Plains, N. Y. *(Assoc. M., Nov. 4, 1903)*	Dec. 5, 1905
Winsor, George Alpha. Asst. Engr., Board of Water Supply, City of New York, P. O. Box 60, Valhalla, N. Y	June 6, 1911
Wise, Colin Reed. City Surv. and Supt., Sewers, 34 Bloomfield Ave., Passaic, N. J	April 6, 1904
Wisner, George Monroe. Chf. Engr., San. Dist. of Chicago, 1500 Am. Trust Bldg., Chicago, Ill	Feb. 4, 1903
Witmer, Francis Potts. Engr. in Chg. of Bridge Designing and Estimating, Am. Bridge Co., 30 Church St., New York City (Res., 32 Mulford St., East Orange, N. J.)	Nov. 30, 1909
Witmer, Joseph Franklin. Hydr. and San. Engr., Chapin Blk., Swan and Pearl Sts., Buffalo, N. Y	May 4, 1904
Witt, Carlton Carpenter. Engr., Kansas Public Utilities Comm., Topeka, Kans	April 6, 1909
Woermann, Frederick Christian. Supt., The R. T. Ford Co., 76 Sheridan Ave., Albany, N. Y	Dec. 6, 1910
Woermann, John William. Asst. Engr., Western Div., U. S. A., 428 Custom House, St. Louis, Mo. *(Assoc. M., May 1, 1895)*	May 7, 1902
Wolf, Julius Herman George. Pres. and Mgr., North Am. Exploration Co., The Exploration Oil Co., 1023 Mills Bldg., San Francisco, Cal. *(Assoc. M., May 7, 1902)*	April 5, 1904
Wolfe, Christian John. 525 Fifty-eighth St., Brooklyn, N. Y	Mar. 6, 1907
Wolfe, Frank Charles. Bridge Engr., West. Md. Ry., 709 Continental Bldg., Baltimore, Md	Jan. 31, 1911
Wölfel, Paul Ludwig. Chf. Engr., McClintic-Marshall Constr. Co., Pittsburgh, Pa. *(Jun., July 3, 1889; Assoc. M., July 1, 1891)*	Nov. 6, 1895
Wolff, Hans Hermann. (Cross & Wolff Eng. & Contr. Co.), 738 Henry Bldg., Seattle, Wash. *(Assoc. M., Jan. 8, 1908)*	Sept. 5, 1911
Wolff, Louis Peter. Cons. Engr., 204 Essex Bldg., St. Paul, Minn	June 30, 1910
Wolstenholme, Albert. 22 Bedford St., Fall River, Mass	June 6, 1906
Wolverton, Irving Mason. Vice-Pres. and Chf. Engr., The Mt. Vernon Bridge Co., Mt. Vernon, Ohio. *(Assoc. M., Dec. 4, 1895)*	Dec. 1, 1903
Wood, Alvinus Brier. Mgr. and Secy., Ore. & S. E. R. R., Cottage Grove, Ore	Sept. 6, 1905

		Date of Membership
	Wood, Dethic Hewitt. Chf. Engr., Converse Bridge Co., 101 Chamberlain Ave., Chattanooga, Tenn. (*Assoc. M., Feb. 6, 1907*)	Nov. 1, 1910
	Wood, Edward Nathan. 1169 Monadnock Blk., Chicago, Ill.	Dec. 5, 1906
	Wood, Frederic James. Civ. Engr. with Stone & Webster, Foxboro, Mass.	Dec. 6, 1905
	Wood, George Pillsbury. Div. Engr., Peekskill Div., New York City Board of Water Supply, Peekskill, N. Y.	June 6, 1911
	Wood, Henry Beecher. Asst. Engr., Harbor and Land Comm., Room 134, State House, Boston, Mass.	April 3, 1895
	Wood, Henry Shotwell. Room 1825, Park Row Bldg., New York City.	May 1, 1907
	Wood, Irving Sparrow. Asst. Engr. in Chg., Water Dept., City Engr.'s Office, City Hall, Providence, R. I. (*Jun., Mar. 5, 1890; Assoc. M., Mar. 7, 1900*)	Mar. 6, 1906
	Wood, Joseph. First Vice-Pres., Penn. Lines W. of Pitts.; Pres., Vandalia R. R., Grand Rapids & Ind. Ry., and Cleveland, Akron & Cin. Ry., 909 Union Station, Pittsburgh, Pa.	April 1, 1874
	Wood, Warren Powell. Chf. Engr., Central Idaho Development Co., Ltd., Lewiston & S. E. Elec. Ry., Ltd., Salmon River Power Co., Ltd., Elec. Ry. Townsite Co., Nezperce & Idaho R. R., and Idaho & N. W. R. R., Sumner, Wash.	July 10, 1907
R.	Woodard, Silas H. Civ. and Cons. Engr. (Noble & Woodard), 7 East 42d St., New York City. (*Assoc. M., Jan. 2, 1901*)	Nov. 1, 1904
	Woodbury, Charles Jeptha Hill. Cons. Engr., 45 Milk St., Boston, Mass.	Dec. 3, 1884
	Woodman, Andrew Whitney. Eng. and Bldg. Constr., 150 Michigan Ave., Chicago, Ill.	Oct. 4, 1905
	Woodruff, Edward Lowrey. Supt., Office of Insp., 18th Lighthouse Dist., San Francisco, Cal.	Oct. 3, 1900
	Woods, Henry Dickinson. 99 Highland St., West Newton, Mass. (*Assoc. M., Mar. 1, 1893*)	June 5, 1895
C.	Woods, Robert Patterson. Chf. Engr., Kansas City Clay Co. & St. Jos. Ry., 1108 Grand Ave., Kansas City, Mo. (*Jun., Feb. 2, 1897; Assoc. M., Mar. 7, 1900*)	April 1, 1903
	Woodworth, Robert Bell. Engr., Carnegie Steel Co., 427 Carnegie Bldg., Pittsburgh, Pa.	April 1, 1908
	Wooldridge, Charles Lawson. Supt. of Public School Bldgs., 314 North Lang Ave., Pittsburgh, Pa.	Oct. 5, 1909
	Woolley, Andrew Feaster. Cons. Engr., 60 Wall St., Room 1901, New York City.	Dec. 2, 1903
	Wooten, William Preston. Maj., Corps of Engrs., U. S. A., U. S. Engr. Office, Honolulu, Hawaii. (*Assoc. M., May 3, 1905*)	Mar. 31, 1908
	Worcester, Joseph Ruggles. Cons. Engr., 79 Milk St., Boston, Mass.	Jan. 2, 1895
	Worthington, Charles. Cons. Engr., Great Neck Station, N. Y. (*Assoc. M., Dec. 1, 1897*)	Nov. 6, 1901
	Wrentmore, Clarence George. Care, Bureau of Public Works, Manila, Philippine Islands. (*Assoc. M., April 5, 1905*)	Oct. 5, 1909
	Wright, Augustine Washington. Cons. Engr., Pomona, Cal.	May 5, 1886
	Wright, Charles Herbert. Chf. Engr., Brown Hoisting Machinery Co., Cleveland, Ohio.	Oct. 5, 1892
	Wright, Edward Thomas. 690 Pacific Elec. Bldg., Los Angeles, Cal.	Feb. 3, 1886
	Wright, John Bertram. Deputy Div. Engr., New York State Highway Comm., 29 Romeyn Ave., Amsterdam, N. Y. (*Assoc. M., May 1, 1907*).	May 31, 1910
	Wright, Joseph. Engr., U. S. Reclamation Service, Intake, Mont. (*Assoc. M., Dec. 7, 1904*)	Aug. 31, 1909
	Wright, Joseph Bodine. Cons. Engr. with Carrere & Hastings, Archts., New York City. (*Assoc. M., June 2, 1897*)	Jan. 31, 1905
	Wright, Parker O, Jr. Archt. and Architectural Engr., 822 Security Bldg., Los Angeles, Cal.	Jan. 4, 1910
	Wright, Willis Benton. Div. Engr., Sewerage and Water Board, 505 City Hall, New Orleans, La.	Nov. 3, 1897
	Wrotnowski, Arthur Francis. Tampico Nav. Co., Hermosillo, Sonora, Mexico.	July 12, 1877

	Yamaguchi, Junnosuke. Director of Eastern Divisonal Supt. Office, Imperial Govt. Rys., Uyeno, Tokyo, Japan.	Mar. 4, 1903
	Yates, Preston King. Cons. Engr., 30 Church St., New York City. (*Jun., June 6, 1883*)	April 5, 1893
	Yeatman, Charles Pope. Grand View, Rhea Co., Tenn.	Feb. 2, 1887
	Yeatman, Morgan Edward. Cons. Engr., Parliament Mansions, Victoria St., London, S. W., England.	May 4, 1892
	Yeatman, Pope. Min. Engr., 165 Broadway, Room 1714, New York City.	Oct. 4, 1893
	Yereance, William Burnet. Cons. Engr., 128 Broadway, New York City. (*Jun., May 3, 1892; Assoc. M., Dec. 2, 1896*)	Mar. 3, 1908
	Yonge, Samuel Humphreys. U. S. Asst. Engr. in Chg. of Impvt., James River, Va., 28 North 9th St., Richmond, Va.	May 5, 1880

		Date of Membership
C.	YORK, HERBERT WALDO. Cons. Engr., Am. Smelting & Refining Co., 165 Broadway, New York City. (*Jun., May 2, 1888*)	June 3, 1896
	YOUNG, ROSCOE CYPRIAN. Chf. Engr., Munising Ry., Marquette & S. E. Ry., Lake Superior & Ishpeming Ry., Marquette, Mich.	Oct. 1, 1902
	YOUNG, SAMUEL MCCAIN. Care, Rome, Ry. & Light Co., Rome, Ga. (*Assoc. M., June 7, 1905*)	Sept. 6, 1910
	YUILLE, NATHANIEL ALSTON. Asst. Engr., U. S. Engr. Office, Box 709, Mobile, Ala. (*Assoc. M., June 6, 1906*)	Nov. 8, 1909
	ZARBELL, ELMER. Office, Chf. Engr., L. & N. R. R., Louisville, Ky. (*Jun., Jan. 3, 1899; Assoc. M., Feb. 7, 1900*)	May 5, 1908
	ZESIGER, ALBERT WILLIAM. Engr. of Constr., Dept. of Bldgs., Cleveland, Ohio	Aug. 31, 1909
	ZIESING, AUGUST. Pres., Am. Bridge Co., 115 Adams St., Room 1324, Chicago, Ill.	Oct. 5, 1898
	ZIFFER, EMANUEL A. Pres. of the Council of Adm. of the Imp. Royal Privileged Lemberg-Czernowitz-Jassy Ry., I Opernring 5, Vienna, Austria	June 7, 1893
	ZINN, AARON STANTON. Res. Engr., Panama Canal, Empire, Canal Zone, Panama	Oct. 5, 1909
	ZINN, GEORGE ARTHUR. Lt.-Col., Corps of Engrs., U. S. A., 508 Federal Bldg., Chicago, Ill.	Feb. 3, 1904
	ZOLLINGER, LUTHER REESE. Engr., M. of W., P. R. R., Broad St. Station, Philadelphia, Pa.	Mar. 6, 1901
	ZOOK, MORRIS ALEXANDER. Cons. Engr., Plainfield, N. J.	Oct. 4, 1899

Members, 2 930.

ASSOCIATE MEMBERS

[Assoc. M. Am. Soc. C. E.]

	Date of Membership
Abbott, Carl Prescott. Box 259, Valhalla, N. Y.	May 2, 1911
Abbott, Hunley. Vice-Pres. and Chf. Engr., MacArthur Concrete Pile & Foundation Co., 11 Pine St., New York City. (*Jun., Sept. 5, 1905*)	Dec. 6, 1910
Abella, Juan. Cons. Engr., Parliament Mansions, Victoria St., Westminster, London, S. W., England	Jan. 6, 1897
Ackenheil, Alfred Curtis. Supt., Lock 29, New York State Barge Canal, Care, The T. A. Gillespie Co., Contrs., Palmyra, N. Y.	April 6, 1909
Ackerman, Alexander Seymour. Engr., Eastern Div., Cape Cod Constr. Co., Sandwich, Mass. (*Jun., April 30, 1907*)	April 6, 1909
Adams, Arthur. Cons. Engr., P. O. Box 17, Halifax, N. S., Canada. (*Jun., Oct. 1, 1901*)	April 6, 1904
Adams, Charles Robert. Asst. Engr., U. S. Geological Survey, North Woodstock, N. H.	Feb. 1, 1910
Adams, Edward Maguire. Capt., Corps of Engrs., U. S. A., Army Bldg., New York City. (*Jun., Oct. 7, 1902*)	Jan. 3, 1906
Adams, Everett Eugene. Asst. to Cons. Engr., U. P. System, S. P. Co., 165 Broadway, Room 2602, New York City	April 1, 1908
Adams, Raymond Edmond. Civ. Engr., War Dept. (Res., 808 Taylor St., N. W.), Washington, D. C. (*Jun., May 1, 1900*)	Dec. 6, 1905
Adey, John Seager. With Monolithic Concrete Constr. Co., Room 1370, Peoples Gas Bldg., Chicago, Ill. (*Jun., Feb. 3, 1903*)	Oct. 3, 1911
Adey, William Henry. Asst. Engr., D. & H. Co., Albany (Res., 181 Main St., Cohoes), N. Y. (*Jun., Feb. 4, 1896*)	Dec. 3, 1902
Adgate, Frederick Whitney. Western Mgr., The Foundation Co., 640 The Rookery, Chicago, Ill.	Jan. 6, 1904
Aegerter, Albert August. 501 Stock Exchange Bldg., St. Louis, Mo.	Mar. 1, 1910
Agramonte, Albert Arthur. Direccion de Desagües, Dolores, F. C. Sud, Buenos Aires, Argentine Republic	Oct. 7, 1908
Aikenhead, James Ray. Punta Gorda, Fla.	Feb. 7, 1906
Albree, Ralph. 112 Western Ave., Pittsburgh, Pa. (*Jun., Oct. 4, 1898*)	Oct. 1, 1902
Alderson, Algernon Brown. 49 Pearl St., Hartford, Conn.	Oct. 2, 1907
Alderson, William Howard. Cons. Engr.'s Office, S. P. Co., U. P. System, 135 Adams St., Room 603, Chicago, Ill. (*Jun., Dec. 5, 1905*)	Mar. 1, 1910
Alexander, Henry James. 103 East 125th St., New York City	Mar. 7, 1906
Alexander, John Howard. 616 Builders Exchange Bldg., Winnipeg, Man., Canada	May 4, 1909
Alexander, Kay. Supt., Hoy & Elzy Co., 810 Metropolitan Opera House Bldg., St. Paul, Minn.	Oct. 2, 1907
Alexander, Robert Lee. With Caughren, Boynton & Co., 320 Hutton Bldg., Spokane, Wash. (*Jun., Nov. 1, 1904*)	Dec. 5, 1906
Alford, William Valorus. Garrettsville, Ohio	Nov. 1, 1910
Allan, Alexander George. Cons. Engr., 746 Equitable Bldg., Denver, Colo.	Mar. 6, 1901
Allardice, Elliot Ritchie Barclay. Supt., Wachusett Dept., Met. Water-Works, Clinton, Mass.	Dec. 6, 1905
Allen, Charles Rollin, Jr. Deputy Div. Engr., State Highway Comm., 202 South 3d Ave., Mechanicsville, N. Y.	June 6, 1911
Allen, Chester Salisbury. Concrete Engr., Lockwood, Greene & Co., 93 Federal St., Boston, Mass. (*Jun., Dec. 4, 1906*)	Oct. 4, 1910
Allen, Eugene Yorke. Supt., Maine Slate Co., Monson, Me.	Dec. 6, 1905
Allen, Frank William. 7 De Kalb Ave., White Plains, N. Y. (*Jun., Nov. 3, 1896*)	May 4, 1898
Allen, Harold Dayton. Asst. Engr., C. R. R. of N. J., 143 Liberty St., New York City. (*Jun., April 30, 1907*)	Dec. 6, 1910
Allen, Jean March. Supt., H. P. Burgard, Barge Canal Contract 37, Fulton, N. Y.	Jan. 31, 1911
Allen, John Lee. Secy., J. L. Fulton & Co., 1553 Monadnock Blk., Chicago, Ill.	Nov. 1, 1905
Allen, Raymond Cleaveland. Manchester, Mass.	Dec. 6, 1910
Allen, Robert Livingston. Care, Archbold-Brady Co., Syracuse, N. Y.	May 6, 1908
Allen, Walter Henry. Municipal and San. Engr., Chehalis, Wash.	Jan. 3, 1911
Allen, William Frederick. Gen. Secy. and Treas., Am. Ry. Assoc., 24 Park Pl., New York City	Jan. 3, 1900

	Date of Membership
Allison, Calvin Tomkins. Gen. Contr., Jones Bldg., Haverstraw, N. Y.	May 1, 1907
Allison, William Franklin. Prof. of Civ. Eng., Colorado School of Mines, Golden, Colo	Oct. 4, 1910
Alsberg, Julius. Engr. with Colgate & Co., Jersey City, N. J	June 3, 1908
Altstaetter, Frederick William. Maj., Corps of Engrs., U. S. A., Wheeling, W. Va	Nov. 6, 1907
Amburn, William Wesley. 265 Eighty-sixth St., Portland, Ore	Sept. 2, 1908
Ames, George Marshall. With Hauser-Owen-Ames Co., 92 Pearl St., Grand Rapids, Mich	June 7, 1899
Ammann, Othmar Hermann. Wissahickon, Philadelphia, Pa	Jan. 8, 1908
Anderberg, Edward. Asst. Engr., Barge Canal Office, Lockport, N. Y. (*Jun., Mar. 5, 1907*)	Mar. 1, 1910
Anders, Frank La Fayette. Cons. Engr. ; City Engr., Fargo, N. Dak	June 6, 1911
Anderson, Charles Louis Bates. Chf. Engr., Clarendon Constr. Co., P. O. Box 513, Wilmington, N. C	May 6, 1908
Anderson, John Gunerius. Asst. Engr., M. & St. L. R. R. and Iowa Cent. Ry., Minneapolis, Minn	Feb. 28, 1911
Anderson, Robert Harlow. Res. Engr., J. G. White & Co., Inc., Parksville, Tenn	Jan. 8, 1908
Anderson, William Townsend. 346 West 71st St., New York City	June 5, 1907
Andress, Harry R. Care, Mississippi River Comm., 1307 Liggett Bldg., St. Louis, Mo	May 31, 1910
Andrew, Clarence Raymond. P. O. Box 152, New Martinsville, W. Va.	April 4, 1911
Andrews, George Crowell. Asst. Engr. in Chg., Contract No. 10, New York State Barge Canal, Fulton, N. Y. (*Jun., Aug. 31, 1909*)	June 30, 1911
Andrews, Robert Edmund. Engr., Committee on Fire Prevention, National Board of Fire Underwriters, 606 Grant Pl., Bay City, Mich	Jan. 2, 1912
Angel, Floyd Dwight. Asst. Engr., U. S. Reclamation Service, Phœnix, Ariz	Oct. 4, 1910
Arce, Julius Andrew. Apartado 90, Arequipa, Peru	Aug. 31, 1909
Archer, Augustus Rowley. Engr., Sales Dept., Carnegie Steel Co., Pittsburgh, Pa.	April 4, 1906
Arend, Albert Cornelius. Cons. Hydr., Municipal and Reinforced Concrete Engr., Brandeis Bldg., Omaha, Nebr	Feb. 2, 1909
Arledge, Arthur Edward. Supt. of Constr., 19th Light-House Dist., Box 615, Honolulu, Hawaii	May 2, 1911
Armitage, George Washington. Supt. of Constr., Army Transport Docks and Seawall, Fort Mason, San Francisco, Cal	April 2, 1902
Armour, Charles Webster L. Fort Smith, Ark	June 1, 1904
Armstrong, Charles Johnstone. Care, *Sir* John Jackson (Canada), Ltd., 706 Canadian Express Bldg., Montreal, Que., Canada	June 6, 1906
Armstrong, Robert Stuart. Engr., Brooklyn Plant, Am. Bridge Co., Ft. of Clay St., Brooklyn, N. Y	Feb. 6, 1907
Armstrong, Roger Wellington. Asst. Desiging Engr., New York Board of Water Supply, West 150th St. and St. Nicholas Pl., New York City	Nov. 8, 1909
Arn, William Godfrey. Asst. Engr., Ill. Cent. R. R., 706 Central Station, Chicago, Ill. (*Jun., Oct. 2, 1900*)	April 6, 1909
Arnott, Robert Fleming. Cons. Engr., 95 Liberty St., New York City	Mar. 2, 1909
Arrington, John. 910 South Michigan Ave., Room 1109, Chicago, Ill	Feb. 28, 1911
Ash, Dorsey. 1023 Mills Bldg., San Francisco, Cal	June 3, 1903
Ashbrook, Chester Daniel. Res. Engr., Canadian North. Ont. R. R., Pearl, Ont., Canada. (*Jun., May 4, 1909*)	June 6, 1911
Atkins, Harold Bedford. Cons. Engr. and Accountant, 1409 West St. Bldg. (Res., 527 West 121st St.), New York City	April 2, 1902
Atkinson, Asher. 11 Pine St., New York City (Res., 49 Mine St., New Brunswick, N. J.)	April 5, 1905
Atterbury, Charles De La Plane. City Engr., Centralia, Wash	Nov. 8, 1909
Atwood, Edward Franklin. Constr. Engr., John T. Scully Foundation Co., 84 First St., Cambridge (Res., 93 Crest Ave., Beachmont), Mass.	June 5, 1907
Avakian, John Caspar. Civ. and Hydr. Engr. ; Pres. and Chf. Engr., Riverside Groves & Water Co., 631 Central Bldg., Los Angeles, Cal.	July 9, 1906
Averill, James Leland. Chf. Engr., Hamilton & Chambers, 29 Broadway (Res., 206 West 106th St.), New York City	Dec. 6, 1910
Avery, Charles Dwight. P. O. Box 335, Cheyenne, Wyo	Jan. 2, 1912
Awoyama, Akira. 12 Yanaka Shimidzucho, Shitayaku, Tokyo, Japan	April 5, 1910
Axtell, Frank Foy. U. S. Junior Engr., Port Arthur, Tex	June 6, 1911
Ayer, Frederic Eugene. Asst. Prof., Civ. Eng., Univ. of Cincinnati, Cincinnati, Ohio.	May 31, 1910
Ayers, Augustine Haines. Prin. Asst. Engr., Lower Div., The Southern Alberta Land Co., Ltd., Suffield, Alta., Canada	Oct. 3, 1911
Aylett, Philip. Engr. of Constr., in Chg., Southern Div., Sewer Dept., St.. Louis, Mo	June 3, 1896
Ayres, John Henry. Asst. Engr., Div. of Water Supply and Sewers, Office of City Engr., Manila, Philippine Islands	Nov. 1, 1910

	Date of Membership
Babcock, William Stuart. Civ. and Waterproofing Engr., 17 Battery Pl., New York City	Feb. 1, 1905
Babé, Joseph Manuel. Chf. Engr. of Bureau of Highways and Bridges, Dept. of Public Works, Arsenal, Havana, Cuba. (*Jun., May 31, 1904*)	Feb. 6, 1907
Backes, William James. Chf. Engr., Cent. New England Ry., 59 Spruce St., Hartford, Conn. (*Jun., May 31, 1904*)	July 9, 1906
Bacon, Arthur Whittemore. Cons. Engr. (Hall & Bacon), National Bank Bldg., New Britain, Conn. (*Jun., Dec. 5, 1905*)	May 3, 1910
Baeta-Neves, Lourenco. Chf. Engr., Technical Dept. of Railways, Public Works and Industries, Bello Horizonte, Minas Geraes, Brazil	Nov. 30, 1909
Bailey, Charles Lester. Asst. Engr., U. S. Reclamation Service, Fort Shaw, Mont	May 2, 1911
Bake, William Sibson. Asst. Engr., G. R. & I. Ry., Office of Chf. Engr., Grand Rapids, Mich	Jan. 4, 1910
Baker, Elisha Brown. Contr., Herkimer, N. Y	April 1, 1896
Baker, Harold James Manning. Junior Engr., U. S. Engr.'s Office, P. O. Box 1809, Seattle, Wash. (*Jun., Oct. 7, 1902*)	Mar. 4, 1908
Baker, Henry Erskine. Engr., Chinese Govt. Paper Mills, Hankow, China	May 7, 1902
Baker, Percival Stevens. Computer, P. & R. Ry., 520 Reading Terminal, Philadelphia, Pa. (*Jun., Sept. 4, 1906*)	Oct. 2, 1907
Baker, Sheldon King. Asst. Engr., U. S. Reclamation Service, Phœnix, Ariz. (*Jun., June 5, 1906*)	Mar. 4, 1908
Balch, Leland Rella. Research Asst. in Hydraulics, Univ. of Wisconsin, Madison, Wis	Oct. 5, 1909
Baldwin, George Clyde. Dist. Engr., Water Resources Branch, U. S. Geological Survey, 615 Idaho Bldg., Boise, Idaho	April 4, 1911
Baldwin, George Herbert. 2632 Channing Way, Berkeley, Cal	Jan. 8, 1908
Baldwin, Hiram Ellsworth. 10532 Earle Ave., Cleveland, Ohio	Jan. 2, 1895
Ball, Laurence Adams. Cons. Engr., 31 Union Sq., New York City. (*Jun., May 3, 1904*)	Feb. 6, 1907
Ballou, Henry Welcome. 735 Banigan Bldg., Providence, R. I	Nov. 7, 1906
Balz, Louis Christian Frederick. 964 South High St., Columbus, Ohio.	Feb. 5, 1908
Bance, Charles William. Engr. and Contr., 1 Montgomery St., Jersey City, N. J	Mar. 5, 1902
Bandy, James Marcus. Cons. Hydr. and San. Engr., Greensboro, N. C.	Feb. 4, 1903
Banks, George Hill. U. S. Engr. Office, Houghton, Mich	Sept. 4, 1907
Banks, John Edwin. Engr., Bureau of Standards, Am. Bridge Co., Ambridge, Pa	June 4, 1902
Bannister, Carl Lincoln. Barge Canal Office, Rome, N. Y	May 3, 1905
Bantel, Edward Christian Henry. Associate Prof. of Civ. Eng., Univ. of Texas, 2307 San Antonio St., Austin, Tex	Feb. 4, 1903
Barker, Charles Whitney Tillinghast. Pres., Field, Barker & Underwood, Inc., Engrs. and Contrs., 718 Arcade Bldg., Philadelphia, Pa. (*Jun., June 6, 1905*)	June 1, 1909
Barker, Ludlow Osmond, Jr. Junior Engr., U. S. Corps of Engrs., Box 266, New Cumberland, W. Va. (*Jun., Jan. 3, 1907*)	Oct. 31, 1911
Barkmann, Ernst Henry. Care, Mo. Val. Bridge & Iron Co., Leavenworth, Kans	Oct. 7, 1908
Barlow, De Witt Dukes. Vice-Pres., Atlantic, Gulf & Pacific Co., 1132 Gresham Rd., Plainfield, N. J	Feb. 7, 1906
Barlow, James Evans. Engr. with Bureau of Municipal Research, 911 Neave Bldg., Cincinnati, Ohio. (*Jun., Sept. 4, 1906*)	Mar. 1, 1910
Barlow, John Sadler. 1222 E. Boulevard, El Paso, Tex	May 6, 1908
Barnard, Elmer Ellsworth. Asst. City Engr., Krise Bldg., Lynchburg, Va. (*Jun., Jan. 31, 1905*)	May 3, 1910
Barnard, Wilfred Keefer. 2711 Ellendale Pl., Los Angeles, Cal	Nov. 8, 1909
Barnes, Frank William, Jr. J. G. White & Co., Parksville, Tenn	Dec. 6, 1910
Barnes, Fred Asa. Asst. Prof., Ry. Eng., Cornell Univ., Ithaca, N. Y	Dec. 7, 1904
Barnes, Walter Esmond. 32 Lincoln St., Malden, Mass. (*Jun., May 6, 1902*)	Dec. 6, 1905
Barney, Percy Canfield. Prin. Asst. Engr., Board of Water Supply, 165 Broadway, New York City. (*Jun., Mar. 3, 1896*)	June 5, 1901
Barratt, Sydney Alfred. Supt., Ponupo Manganese Co., Santiago de Cuba, Cuba	April 1, 1908
Barrett, Robert Edward. Asst. Engr., Board of Water Supply of the City of New York, 250 West 54th St., New York City. (*Jun., Jan. 31, 1905*)	Dec. 6, 1910
Barrows, George Ellsworth. Care, Ellsworth Bros., 50 West Eagle St., Buffalo, N. Y	May 2, 1911
Bartell, Max John. Asst. Engr., City Engr.'s Office, Hewes Bldg., San Francisco, Cal. (*Jun., May 1, 1906*)	Oct. 5, 1909
Bartlett, Charles Terrell. Civ. and Structural Engr. (Bartlett & Ranney), F Bldg., San Antonio, Tex	Jan. 2, 1912
Bartoccini, Astolfo. Contr. Engr., 261 Broadway, New York City	May 6, 1903
Barton, Calvin Lewis. Vice-Pres., McHarg-Barton Co., Contrs., 165 Broadway, New York City	April 4, 1906

	Date of Membership
Barton, Walter Chew. 3d Floor, Metropolitan Bank Bldg., New Orleans, La	July 1, 1908
Bascome, Western Radford. Asst. to Chf. Engr., Dept. of Bridges, 140 Claremont Ave., New York City. (*Jun., Dec. 3, 1891*)	May 5, 1897
Bass, Fred Thomson. Care, Post & McCord, 44 East 23d St., New York City	May 2, 1911
Bassell, Guy Mannering. Care, Knoxville Power Co., Chilhowee, Tenn	Feb. 6, 1907
Bassett, Robert Jay. Supt., Constr., New Prison, Comstock, N. Y. (*Jun., Feb. 3, 1903*)	Feb. 3, 1904
Batchelder, Benjamin Franklin. Potsdam, N. Y	Jan. 4, 1910
Bates, John Schuyler. Chf. Engr., Fresno, Coalinga & Tidewater Co., 353 Jensen Ave., Fresno, Cal	Mar. 1, 1910
Bates, William Bernard. Cons. Engr. (Huggins & Bates), 6th Floor, Strickland Bldg., Roanoke, Va	Nov. 6, 1907
Batson, Charles Drewry. Local Mgr., Republic Creosoting Co., Mobile, Ala	Oct. 3, 1911
Baum, Frank George. Cons. Elec. and Hydr. Engr., Chronicle Bldg., San Francisco, Cal	July 9, 1906
Bausher, Carmi Irving. Asst. Engr., B. and C. Dept., The Penna. Steel Co., Steelton; 136 North 13th St., Harrisburg, Pa	Dec. 7, 1898
Baxter, David Elder. 32 West 60th St., New York City. (*Jun., May 2, 1899*)	July 9, 1906
Bayley, Charles Abercrombie Dunbar. 24 Union St., Montclair, N. J.	Dec. 1, 1908
Baylis, Arthur Raymond. Ewing, Bacon & Henry, 30 Church St., New York City	June 6, 1906
Beach, James George. Archt. (Doyle, Patterson & Beach), 401 Worcester Bldg., Portland, Ore. (*Jun., Aug. 31, 1897*)	Sept. 2, 1903
Beach, William Nicholas. 29 Broadway, New York City	July 1, 1909
Beal, George Safford. Res. Engr., Lake Altoona, 1810 Thirteenth St., Altoona, Pa	June 6, 1906
Beale, Carroll. Contr. Engr., Pittsburgh Steel Co., Singer Bldg., New York City	Oct. 5, 1909
Beale, Harry Orlando. Care, U. S. Reclamation Service, Fort Shaw, Mont	Oct. 5, 1909
Bebb, Edward Crosby. Engr., U. S. Reclamation Service, Washington, D. C	Nov. 6, 1907
Bebout, Guy Burnet. Junior Engr., U. S. Engr. Office, Wheeling, W. Va.	June 30, 1910
Becker, Elvin Jay. Asst. Engr. in Chg. of Constr., Contract No. 11, Barge Canal, Waterford, N. Y. (*Jun., April 3, 1906*)	Mar. 1, 1910
Becker, Sylvanus A. Instr. in Civ. Eng., Lehigh Univ., 103 North St., Bethlehem, Pa. (*Jun., Dec. 1, 1903*)	Feb. 5, 1908
Beebe, Henry Rumrill. 15 Avery Pl., Utica, N. Y	May 2, 1911
Beebe, James Wilbur. Prescott, Ark	Dec. 5, 1911
Beekman, John Vanderveer, Jr. Gen. Mgr., Whidden & Co., Inc., 155 Milk St., Boston, Mass. (*Jun., Sept. 3, 1901*)	July 10, 1907
Beer, Paul. Mgr., The Barber Asphalt Pav. Co., Des Moines, Iowa	Oct. 4, 1905
Beeson, Alexander Conn. Chf. Engr., Pittsburgh-Buffalo Co., 408 Frick Bldg., Pittsburgh, Pa	May 1, 1907
Begien, Ralph Norman. Asst. to Gen. Mgr., B. & O. R. R., B. & O. Bldg., Baltimore, Md	June 7, 1905
Belcher, Donald Minor. 14 Prospect St., Winchester, Mass	Oct. 31, 1911
Belcher, Wallace Edward. Structural Engr., H. M. Byllesby & Co., Inc., 218 La Salle St., Chicago, Ill. (*Jun., Dec. 2, 1902*)	June 3, 1908
Belknap, Francis Wheelwright. Engr. and Gen. Mgr., Phœnix Constr. Co., 41 Park Row, New York City	Feb. 1, 1905
Bell, Alfred Carroll. Contr. Engr., Wisconsin Bridge & Iron Co., 605 Colby-Abbot Bldg., Milwaukee, Wis. (*Jun., May 2, 1893*)	Jan. 2, 1901
Bell, Joseph Edgar. Care, U. S. Reclamation Service, Lahontan, *via* Hazen, Nev	Oct. 3, 1911
Bellows, Daniel Everett. Asst. Engr., N. Y. State Barge Canal, Box 68, Clyde, N. Y. (*Jun., April 30, 1907*)	July 1, 1908
Benedict, Farrand Northrop. Engr., Thomas Crimmins Contr. Co., 24 East 99th St., New York City. (*Jun., June 4, 1907*)	May 2, 1911
Benedict, Harold Willoughby. Asst. Engr., New York State Barge Canal, 705 Third Ave., North, Troy, N. Y	Jan. 3, 1911
Benham, Webster Lance. Contr. Engr., The Benham Eng. Co., 812 Am. National Bank Bldg., Oklahoma, Okla	April 5, 1910
Bennett, Charles Noble. Warrenton, Ore	Dec. 4, 1907
Benson, Newton Davis. Engr. and Contr., 3 Circuit Drive, Edgewood Station, Providence, R. I	July 10, 1907
Bentley, John Clark. 511 Sixteenth St., Watervliet, N. Y	May 31, 1910
Bergendahl, Gustave Storm. Pres., Bergendahl-Bass Eng. & Const. Co., 1311 Harriss Trust Bldg., Chicago, Ill	April 3, 1907
Berger, Bernt. Cons. Engr., 45 Broadway, New York City	April 5, 1893
Berger, John. Room 5139, Grand Central Terminal, New York City	Oct. 2, 1907
Berry, Claude. Care, Modern Steel Structural Co., Waukesha, Wis	Feb. 6, 1907

	Date of Membership
Berry, Francis Rigdon. Box 162, Suffolk, Va. (*Jun., Dec. 2, 1902*)	Nov. 8, 1909
Berry, Herman Claude. Asst. Prof., Materials of Constr., Univ. of Pennsylvania, Philadelphia, Pa	Oct. 31, 1911
Berry, Leslie Graham. Mgr., Southern Eng. Co., Realty Bldg., Charlotte, N. C	Dec. 1, 1908
Best, John Henry. Pres. and Gen. Mgr., Best Constr. Co., Wapato, Wash	June 1, 1904
Betts, Edward Everett. Chf. Engr., Hamilton County Rd. Comm., Chattanooga, Tenn	April 5, 1899
Beugler, Charles Ernest. 6509 Wheeler St., Oakland, Cal	Oct. 2, 1907
Bevan, Lynne John. Asst. Engr., Vielé, Blackwell & Buck, 49 Wall St., Room 601, New York City	May 3, 1910
Bilger, Harry Edmund. Care, State Highway Comm., Springfield, Ill	Aug. 31, 1909
Billingsley, James Wartelle. Associated with The Fred A. Jones Co., Houston, Tex	May 6, 1908
Binford, Charles Munnerlyn. Asst. Mgr. and Engr., Piney Min. Co., Stanaford (Res., Riley), W. Va	Dec. 6, 1910
Bingham, Clarence Arminger. City Engr. and Cons. Municipal Engr., Carlisle, Pa. (*Jun., June 5, 1906*)	Jan. 4, 1910
Bischoff, Julius Montgomery. Asst. Engr., Cuban Central Rys., Ltd., Sagua la Grande, Cuba	Jan. 4, 1910
Bishop, Lyman Edgar. Location Engr., The Goldsborough Co., First National Bank Bldg., Denver, Colo. (*Jun., May 4, 1909*)	Oct. 31, 1911
Bissell, Clinton Talcott. Structural Engr., Committee on Fire Prevention, National Board of Fire Underwriters, 135 William St., New York City	Dec. 5, 1906
Bixby, Frederick Louis. Irrig. Engr., Irrig. Investigations in New Mexico, U. S. Dept. of Agri.; Prof. of Civ. and Irrig. Eng., New Mexico Coll. of Agri. and Mechanic Arts, Agricultural College, N. Mex.	June 6, 1911
Bixby, William Flint. City Engr., Sierra Madre and Eagle Rock; Civ. and Hydr. Eng. (Bixby & White), 502 Mason Bldg., Los Angeles, Cal. (*Jun., Feb. 5, 1907*)	April 5, 1910
Blaauw, Geert. Designing Engr., Long Sault Development Co. and St. Lawrence River Power Co., Massena, N. Y	Nov. 30, 1909
Black, Edward Fryling. Instr. in Eng., Anglo-Chinese Coll., Foochow, China. (*Jun., Oct. 31, 1905*)	Nov. 4, 1908
Black, Ernest Bateman. Cons. Engr. (Worley & Black), Kansas City, Mo	Nov. 1, 1910
Black, Gurdon Gilmore. Engr. in Chg., Supply and Purifying Div., St. Louis Water Dept., 34 East Grand Ave., St. Louis, Mo	Oct. 5, 1909
Black, Ralph Peters. Engr., M. of W., Kanawha & Mich. Ry., Charleston, W. Va	Nov. 8, 1909
Blackmore, George Glover. Constr. Engr. and Supt., 150 Lexington Ave., New York City	Nov. 30, 1909
Blackwell, Paul Alexander. Asst. Chf. Engr., Virginia Bridge & Iron Co., Roanoke, Va. (*Jun., Dec. 4, 1900*)	Jan. 3, 1906
Blair, Clarence Moore. 99 Norton St., New Haven, Conn	Dec. 5, 1911
Blair, McCrea Parker. City Engr., City Hall., St. Boniface, Man., Canada	Feb. 2, 1909
Blamphin, Arthur Merrick Newberry. Asst. City Engr., Room 19, City Hall, New Orleans, La. (*Jun., Dec. 3, 1907*)	Feb. 2, 1909
Blanchard, Arthur Clarence Douglas. City Engr., Lethbridge, Alta., Canada	April 5, 1910
Bland, Miles Carlisle. Engr., The Canton Bridge Co., Canton, Ohio	Sept. 3, 1902
Blatt, Max. Asst. Engr., Dept. of Water Supply, Gas and Electricity (Res., 811 Cauldwell Ave.), New York City	Oct. 5, 1909
Blaylock, John Charles. Structural Engr., Hansell-Elcock Co., Chicago, Ill	Mar. 2, 1909
Bliem, Daniel William. 'Asst. to Operating Mgr., Am. Bridge Co., Pennsylvania Bldg., Philadelphia, Pa	June 5, 1907
Bliss, Edwin Packard. Cons. and Con. Engr. (H. P. Converse & Co.), 88 Broad St., Boston, Mass	July 9, 1906
Bliss, George Henry. Div. Engr., U. S. Reclamation Service, Boise, Idaho	Sept. 7, 1904
Blood, Charles Frederick. Engr. and Contr., 15 Wall St., Room 3, New York City	Oct. 5, 1909
Boardman, Harold Sherburne. Dean of Coll. of Technology; Prof. of Civ. Eng., Univ. of Maine, Orono, Me	Feb. 3, 1904
Boardman, Howard Edward. Div. Engr., Mo. Pac. Ry., Atchison, Kans. (*Jun., Oct. 7, 1902*)	Jan. 4, 1905
Boatrite, James Edwin. Gen. Mgr., The Guerber Eng. Co., Bethlehem, Pa. (*Jun., Feb. 5, 1895*)	Nov. 3, 1897
Bobbs, Arthur Lee. Cons. Structural Engr., 68 Post St., San Francisco, Cal	Jan. 2, 1912
Bogen, Louis Edward. Chf. Elec. Estimating Engr., The Allis-Chalmers Co. (Res., 171 Twenty-first St.), Milwaukee, Wis. (*Jun., April 30, 1895*)	June 4, 1902

	Date of Membership
Boller, Alfred Pancoast, Jr. 45 East 17th St., New York City. (*Jun., Oct. 2, 1894*)	May 3, 1899
Boltz, Thomas Franklin. Asst. Engr. and Supt. of Constr., Pacific & Eastern R. R., Eagle Point, Ore	Oct. 5, 1909
Bond, George Washington, Jr. Township Engr., Weehawken, N. J	Nov. 1, 1905
Bond, Judson Baker. Project Engr., U. S. Reclamation Service, Fort Shaw, Mont	June 3, 1908
Boniface, Arthur. Asst. Engr., Rapid Transit Subway Constr. Co., 165 Broadway, New York City. (*Jun., Jan. 2, 1906*)	Oct. 4, 1910
Bonnett, Charles Pierre. Asst. Engr., Topographical Bureau, Borough of the Bronx (Res., 241 West 101st St.), New York City. (*Jun., June 2, 1886*)	Mar. 6, 1901
Booz, Horace Corey. Asst. Chf. Engr., P. R. R., Room 613, Broad St. Station, Philadelphia, Pa	April 4, 1906
Borchers, Perry Elmer. Contr. Engr., 218 National Bank of Arizona Bldg., Phœnix, Ariz	Jan. 2, 1912
Bortin, Harry. Asst. Engr., U. P. R. R., 320 North 20th St., Omaha, Nebr. (*Jun., Sept. 6, 1910*)	Jan. 2, 1912
Bos, George Albert. Cons. Engr., Associated with Lewis P. Hobart, Archt., Crocker Bldg., San Francisco, Cal	June 3, 1908
Boschke, Guy. Mgr., at Portland, Ore., for W. N. Concanon Co., Const. Engrs., Portland, Ore	Feb. 28, 1911
Boucher, William James. With Mineral Point Zinc Co., Nassau Plant, Depue, Ill	Sept. 6, 1905
Boude, Philip Bethel. Engr. and Contr. (Torrington & Boude), Room 48, Third National Bank Bldg., Cumberland, Md	Mar. 1, 1910
Boughton, Will Hazen. Treas., Business Mgr. and Cons. Engr., Vassar Coll., Box 353, Poughkeepsie, N. Y	Nov. 6, 1907
Bouillon, Arthur Maximillien. Dist. Engr., G. T. P. Ry., St. John, N. B., Canada	June 6, 1911
Bourguignon, Joseph. 236 State St., Flushing, N. Y	May 31, 1910
Bourne, Thomas Johnstone. Dist. Engr., Tientsin-Pukow Ry. (Southern Section), Nanking, China	Feb. 7, 1900
Bowditch, John Henry. Asst. Div. Engr., N. Y. Div., B. & O. R. R., New Brighton, N. Y	July 10, 1907
Bowen, Edmund Ignatius. Supt., Delaware and Jefferson Divs., Erie R. R., Susquehanna, Pa	Nov. 1, 1899
Bowen, Edward Rose. 1110 Central Bldg., Los Angeles, Cal	Jan. 2, 1912
Bowen, Sherman Worcester. Structural Engr., 5945 Cote Brilliante Ave., St. Louis, Mo	Sept. 7, 1904
Bowie, Clifford Pinkney. Engr., Associated Pipe Line Co., Wells-Fargo Bldg., San Francisco, Cal	Aug. 31, 1909
Bowler, Frank Colburn. Chf. Engr., Great Northern Paper Co., Millinocket, Me	Oct. 5, 1904
Bowles, Charles William. Chf. Engr. and Mgr., Patiala State, Patiala, Punjab, India	Sept. 6, 1910
Bowles, Clayton Wass. City Engr., Glendive, Mont	Jan. 3, 1911
Bowne, William Hunt. Glen Cove, N. Y	Dec. 7, 1904
Boyd, Butler Bennett. Duncans, B. C., Canada	Nov. 8, 1909
Boyd, Robert Wright. Cons. Engr., 105 West 40th St., New York City	Jan. 8, 1908
Bradbury, Richard Robertson. Pleasantville, N. Y	Jan. 31, 1911
Bradshaw, Charles. Care, Bureau of Public Works, Manila, Philippine Islands	Nov. 6, 1907
Bradshaw, Sam Wigfall. Asst. Engr., Estimating Dept., Bridge and Constr. Dept., Pennsylvania Steel Co., Steelton, Pa. (*Jun., Oct. 2, 1900*)	Feb. 4, 1903
Brainard, Albert Sereno. Highway Engr., 9 Burnside Ave., East Hartford, Conn. (*Jun., Oct. 6, 1908*)	June 6, 1911
Branch, Lester Van Noy. Div. Engr., Guayaba Dam, Porto Rico Irrig. Service, Juana Diaz, Porto Rico	June 3, 1908
Branch, Thomas Pettus. Prof., Civ. Eng., Georgia School of Technology, Atlanta, Ga	Feb. 5, 1902
Branne, John Severin. Cons. Engr., 1 Madison Ave., New York City (Res., 145 Chester St., Mt. Vernon, N. Y.)	Oct. 5, 1898
Bratton, Edward Elisha. Vice-Pres. and Engr., The Bratton Co., Engrs. and Contrs., Philadelphia, Pa	Oct. 2, 1907
Braune, Gustave Maurice. Contr. Engr., 622 Woodward Bldg., Birmingham, Ala. (*Jun., June 2, 1896*)	Sept. 4, 1901
Braunworth, Percy Lewis. Cons. Engr. (Farley & Braunworth), Trenton, N. J	Jan. 3, 1911
Breed, Henry Eltinge. Asst. Chf. Engr., Coleman du Pont Road, Inc., du Pont Bldg., Wilmington, Del	Mar. 4, 1908
Breneman, Paul Bruce. Prof. of Mechanics and Materials of Constr., in Chg. of The Laboratory for Testing Materials, The Pennsylvania State Coll., State College, Pa	Mar. 2, 1909
Brenn, Charles Ferdinand. Chf. Engr. of Mines, C., M. & St. P. Ry., 305 Maloney Bldg., Ottawa, Ill	May 4, 1904

	Date of Membership
Brereton, Thomas John. Pres., Val. Spirit Pub. Co., Chambersburg, Pa. (*Jun., Oct. 7, 1885*)	June 5, 1895
Brett, Lawrence. Pres. and Gen. Mgr., Brett Eng. & Contr. Co., Wilson, N. C	Feb. 6, 1912
Breuchaud, Jules Rowley. 290 Broadway, New York City. (*Jun., Nov. 1, 1904*)	May 2, 1911
Briggs, Harry Alson. Engr. with MacArthur Bros. Co., Brown Station, N. Y	May 1, 1907
Bright, Charles Edwin. U. S. Supt., Colbert Shoals Canal, Riverton, Ala.	Dec. 3, 1902
Brillhart, Jacob Herbst. Chf. Engr., The Guerber Eng. Co. (Res., 342 North Seventh Ave.), Bethlehem, Pa. (*Jun., Nov. 1, 1904*)	Nov. 4, 1908
Brink, Lawrence Calvin. Gen. Supt., Pittsburgh Contr. Co., 3785 Broadway, New York City	Oct. 7, 1908
Brinkley, Milo Hamilton. Care, J. G. White & Co., 334 California St., San Francisco, Cal. (*Jun., Mar. 1, 1904*)	Jan. 8, 1908
Brinsmade, Daniel Edwards. Secy. and Asst. Treas., The Ousatonic Water Power Co., Box 95, Derby, Conn	April 6, 1904
Brock, David Morrice. U. S. Engr. Office, P. O. Box 1027, Memphis, Tenn.	Sept. 5, 1911
Brodie, Orrin Lawrence. Asst. Designing Engr., Board of Water Supply, 165 Broadway, New York City	July 10, 1907
Brogan, Thomas Byrnes. Insp., Board of Water Supply of New York City, 596 Riverside Drive, New York City	Feb. 1, 1910
Brook-Fox, Evelyn. Care, National Bank of India, Calcutta, India	Feb. 2, 1898
Brooke, George Doswell. Asst. Supt., B. & O. R. R., Cumberland, Md.	Nov. 7, 1906
Brooks, John Pascal. Director, Clarkson School of Technology, Potsdam, N. Y	April 1, 1896
Brooks, Miles Elijah. Locating Engr., Kettle River Val. Ry., Princeton, B. C., Canada	July 9, 1906
Brower, Edward Sylvester. Cons. Engr., 95 Liberty St., New York City.	Dec. 2, 1903
Brower, Irving Clinton. Asst. Engr., C. & N. W. Ry., Care, E. C. Carter, Chf. Engr., Chicago, Ill	Nov. 30, 1909
Brown, Alfred Thomas. Asst. Engr., Board of Water Supply, White Plains, N. Y. (*Jun., Nov. 1, 1904*)	Jan. 5, 1909
Brown, Burtis Scott. Cons. Engr., 88 Broad St., Boston, Mass	Oct. 5, 1909
Brown, Charles Eugene. Res. Engr., Key West Terminal, Florida East Coast Ry., Key West, Fla	Mar. 4, 1908
Brown, Charles Franklin. Newhouse Bldg., Salt Lake City, Utah	Oct. 7, 1908
Brown, Clark. Barge Canal Office, Albany, N. Y	April 1, 1908
Brown, Collingwood Bruce, Jr. Div. Engr., C. P. Ry., Montreal, Que., Canada. (*Jun., Oct. 1, 1901*)	April 6, 1909
Brown, Elliot Chipman. 27 William St., New York City	Oct. 31, 1911
Brown, George Rowell. Asst. to Div. Engr., Div. No. 1, Mass. Highway Comm., 167 West Housatonic St., Pittsfield, Mass	Jan. 2, 1912
Brown, Grover Charles. Care, Enrique Ruiz Williams, Solis 72, Sagua la Grande, Cuba. (*Jun., June 2, 1908*)	May 2, 1911
Brown, Harry William. Asst. Div. Engr., P., C., C. & St. L. Ry., Logansport, Ind	April 5, 1910
Brown, Marshall Wright. 137 South Broadway, Nyack, N. Y	Nov. 4, 1908
Brown, Robert Huse. 21 West 127th St., New York City. (*Jun., June 6, 1905*)	April 5, 1910
Brown, Robert King. Engr., M. of W., S. P., L. A. & S. L. R. R., Room 228, Union Station, Salt Lake City, Utah	June 7, 1893
Brown, Rodman Merritt. Pres., Brown & Read Co., Engrs. and Contrs., 1212 Hartford Bldg., Chicago, Ill	Feb. 1, 1905
Brown, Samuel Coughlin. 15 West 83d St., New York City	Nov. 1, 1905
Brown, Seymour Dewey. Brazil Ry., 9 Rue Louis le Grand, Paris, France.	Oct. 4, 1910
Brownell, Leonard Dempster. Asst. Engr., Dept., State Engr. and Surv., 112 South Chester St., Syracuse, N. Y	Nov. 6, 1907
Brownlee, James Lawrence. Junior Engr., Big Eddy, Ore	Feb. 28, 1911
Bruce, John Augustus. Sewer Engr., City of Omaha; Civ. and Municipal Engr. (The Consolidated Eng. Co.), 206 Bee Bldg., Omaha, Nebr	Sept. 6, 1910
Bruning, Henry Diedrich. Acting Prof., Civ. Eng., Ohio State Univ., 2401 Neil Ave., Columbus, Ohio	Oct. 7, 1908
Brunnier, Henry John. Cons. Structural Engr., 651 Monadnock Bldg., San Francisco, Cal	Jan. 3, 1911
Bruntlett, Eugene Harry. 4808 South Lyndale Ave., Minneapolis, Minn. (*Jun., June 6, 1905*)	June 30, 1910
Brush, Carl Fletcher. City Engr., Lakeland, Fla	Mar. 4, 1908
Brush, William Whitlock. Deputy Chf. Engr., Dept. of Water Supply, Gas and Electricity, 13 Park Row, New York City. (*Jun., Mar. 3, 1896*)	April 5, 1905
Bryson, Thomas Bines. Contr. Engr., 331 Madison Ave., New York City.	Feb. 7, 1900
Buck, Con Morrison. Cons. Engr., 615 Poyntz Ave., Manhattan, Kans.	Dec. 6, 1905
Buerger, Charles Bernard. Asst. Engr., Dept. of Water Supply, Gas and Electricity, 2418 Park Row Bldg., New York City	April 4, 1911
Bugbee, Newton Albert Kendall. 207 Academy St., Trenton, N. J	Oct. 5, 1904

	Date of Membership
Bullen, Roy. Logan, Utah. (*Jun., May 1, 1906*)	Mar. 1, 1910
Bumsted, Eugene Bradford. Hydr. Engr., Stone & Webster Eng. Corporation, Reno, Nev. (*Jun., May 1, 1900*)	Mar. 6, 1907
Bunker, Stephen Sans. Care, Madeira-Mamoré Ry., P. O. Box 304, Manãos, Brazil	Oct. 4, 1910
Bunnel, William Cyrus. U. S. Asst. Engr., U. S. Engr. Office, Box 155, Manila, Philippine Islands. (*Jun., Oct. 1, 1901*)	Jan. 2, 1907
Burchard, Anson Wood. 21 Front St., Schenectady, N. Y	May 3, 1893
Burden, Morton. Care, Eng. Dept., Am. Bridge Co., Frick Bldg., Pittsburgh, Pa. (*Jun., Feb. 4, 1896*)	Jan. 2, 1901
Burgoyne, John Henry, Jr. Locating Engr., Oroya-Chauchamayo R. R., Oroya, Peru. (*Jun., Sept. 1, 1903*)	Dec. 5, 1906
Burke, Ralph Haney. 10911 Grove St., Morgan Park, Ill. (*Jun., Dec. 4, 1906*)	Oct. 4, 1910
Burnette, Chauncey Allison. Contr. Bridge Engr., 527 Central Bldg., Seattle, Wash	June 6, 1911
Burns, Joseph Patrick. 339 Franklin St., Watertown, N. Y	Dec. 1, 1908
Burns, Louis Andrew. Res. Engr. in Chg., Carthage to Lake Ontario Canal Project, Dept., New York State Engr., 45 Savings Bank Bldg., Watertown, N. Y	July 1, 1909
Burns, Walter Elliott. 911 O St., Sacramento, Cal. (*Jun., Mar. 5, 1907*)	Dec. 6, 1910
Burpee, George William. With Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City. (*Jun., Sept. 3, 1907*)	Sept. 5, 1911
Burrage, John Otis. Cons. Engr., 3400 Washington St., San Francisco, Cal. (*Jun., Mar. 1, 1904*)	Nov. 4, 1908
Burrell, Glenn Smith. Asst. Civ. Engr., U. S. N.; Asst. to Public Works Officer, U. S. Navy Yard, Norfolk, Va	Aug. 31, 1909
Burroughs, Frederic. 621 North St. Clair St., Pittsburgh, Pa. (*Jun., June 4, 1907*)	May 3, 1910
Burroughs, Hector Robins. Cons. Engr., 30 Church St., New York City. (*Jun., Mar. 3, 1908*)	Sept. 6, 1910
Burt, Luther Harold. Cons. Engr., 39 Pearl St., Hartford, Conn	Nov. 1, 1910
Burton, William. 270 Midland Ave., Upper Montclair, N. J. (*Jun., Oct. 3, 1905*)	May 4, 1909
Burwell, Robert Lemmon. Asst. Div. Engr., Baltimore Sewerage Comm., Am. Bldg. (Res., 1307 Bolton St.), Baltimore, Md. (*Jun., Dec. 3, 1901*)	July 1, 1908
Bush, Adam Leonard. Chf. Engr. for Parkinson & Bergstrom, 1035 Security Bldg., Los Angeles, Cal	Oct. 4, 1910
Bush, Philip Lee. Chf. Engr., California Fruit Canners Assoc., 120 Market St., San Francisco, Cal	Sept. 5, 1906
Bushnell, Howard Emory. Contr. Engr., Levering & Garrigues Co., Firemen's Ins. Bldg., Newark, N. J. (*Jun. Mar. 6, 1906*)	June 6, 1911
Busse, Franz August. 800 Third St., Louisville, Ky	April 5, 1910
Butchers, Earle Burdette. Draftsman for Am. Bridge Co., Ambridge, Pa	Jan. 8, 1908
Butler, Alfred Dickey. Chf. Asst. City Engr., Spokane, Wash	Oct. 5, 1909
Butler, George. County Surv., Court House, San Diego, Cal	Sept. 6, 1910
Butler, John Soule. U. S. Junior Engr., Lock and Dam No. 21, Palace, Ky	Mar. 4, 1908
Butler, Millard Angle. Asst. Engr., G. N. Ry., 912 East Sinto Ave., Spokane, Wash	Jan. 3, 1911
Butterfield, Herbert Mitchell. Care, Riley, Hargreaves & Co., 5 Battery Rd., Singapore, Straits Settlements	Oct. 3, 1906
Butz, George Wishart. Cons. Engr., Schuylkill Haven, Pa	April 6, 1909
Buzzell, Josiah William. With Stone & Webster Eng. Corporation, 5 Nassau St., New York City	April 6, 1904
Byrd, John Henry. Engr. in Chg., Design, Bridges and Subways, Kansas City Terminal Ry., 4427 Troost Ave., Kansas City, Mo	Jan. 2, 1912

Cadle, Charles Longford. Elec. Engr., New York State Rys., Rochester, N. Y	Nov. 1, 1910
Cahill, James Edward. Engr., Great Lakes Dredge & Dock Co., Chamber of Commerce (Res., 1221 Gilpin Pl.), Chicago, Ill. (*Jun., Mar. 31, 1908*)	Oct. 3, 1911
Cahn, Elias. 103 West 141st St., New York City	June 6, 1911
Caldwell, Fred Edward. Newton, N. J. (*Jun., April 3, 1906*)	Feb. 1, 1910
Calhoun, David Adams. Cons. Engr., 35 Nassau St., New York City. (*Jun., Oct. 6, 1908*)	May 31, 1910
Cameron, Harry Frank. Div. and Chf. Engr., Osmeña Water-Works System, Cebu, Philippine Islands	Oct. 2, 1907
Cameron, John Bobbs. Asst. Engr., Constr. Dept., B. & O. R. R., Somerset, Pa. (*Jun., Oct. 2, 1900*)	Feb. 3, 1904

	Date of Membership
CAMPBELL, DUNCAN HUGH. Care, Rio de Janeiro Tramway, Light & Power Co., Avenida Central 76, Rio de Janeiro, Brazil	July 1, 1909
CAMPBELL, HENRY AVERY. Engr., Bureau of Inspection, 1209 Merchants Exchange Bldg., San Francisco, Cal. (*Jun., April 4, 1905*)	April 6, 1909
CARBAJAL, FERNANDO. P. O. Box 315, Lima, Peru. (*Jun., Jan. 7, 1908*)	Oct. 3, 1911
CARBERRY, RAY SHEPPARD. Supt., Imperial Water Co. No. 1, Imperial, Cal.	Mar. 4, 1908
CAREY, EDWARD GILMAN. Asst. Engr. with E. De V. Tompkins, 17 East 38th St., New York City	July 1, 1909
CARHART, FRANK MILTON. Chf. Carey Act Engr., State of Idaho, P. O. Box 311, Boise, Idaho	Nov. 8, 1909
CARO, PHILLIP. University Club, Castlereagh St., Sydney, N. S. W., Australia	Nov. 1, 1910
CARPENTER, CLARENCE EDSON. Road Engr., Interborough Rapid Transit Co., New York City, 33 Bruce Ave., Yonkers, N. Y.	July 10, 1907
CARR, DEAN ORRICE. Bridge Engr., Am. Bridge Co., Gary, Ind.	Oct. 4, 1910
CARRICK, ROBERT EDWARD. Engr., The Gen. Fireproofing Co., 257 East 133d St., New York City. (*Jun., April 30, 1907*)	April 6, 1909
CARROLL, CHARLES JOSEPH. With Parker & Carroll, Apartado No. 208, Durango, Mexico	Oct. 5, 1904
CARSTARPHEN, FREDERICK CHARLES. 514 Ideal Bldg., Denver, Colo.	April 6, 1909
CARTER, CLARENCE ELMORE. Res. Engr., Twin Falls North Side Land & Water Co., Jerome, Idaho	Oct. 3, 1911
CARTER, FRANK HARVIE. Designing and Superv. Engr., 147 Magazine St., Cambridge, Mass.	Jan. 4, 1905
CARVER, GEORGE PAYSON. 53 State St., Boston, Mass.	Oct. 2, 1907
CASANI, ALBERT AENEAS. Instr., Structural Design, School of Industrial Arts, Columbia Univ., 561 West 180th St., New York City	Jan. 2, 1912
CASE, GEORGE WILKENSON. Asst. Prof., Civ. Eng., Purdue Univ.; 517 East Buffalo St., Ithaca, N. Y.	Sept. 6, 1910
CASLER, MELVIN DAVID. 107 North High St., Mt. Vernon, N. Y.	Sept. 5, 1911
CAUTHORN, EDWARD BEAUFORD. City Engr., Columbia, Mo.	June 5, 1907
CHACE, IRA MASON, JR. Mgr., New Bedford Office, J. W. Bishop Co., Gen. Contrs., New Bedford, Mass.	Oct. 2, 1907
CHADBOURNE, EDWARD MERRIAM. Pres. and Gen. Mgr., E. M. Chadbourne Co., Engrs. and Contrs., 800 Postal Telegraph Bldg., San Francisco, Cal. (*Jun., Nov. 3, 1903*)	Oct. 2, 1907
CHADWICK, CHESTER ROBERT. Structural Engr., Milliken Bros., Inc., Milliken, N. Y. (*Jun., Feb. 5, 1907*)	Feb. 28, 1911
CHAMBERLAINE, ROBERT LLOYD. Engr. of Way, United Rys. & Elec. Co., 1008 Continental Bldg., Baltimore, Md.	Oct. 2, 1907
CHAMBERS, HENRY WICK. Asst. Engr., Office of Vice-Pres. and Gen. Mgr., N. Y. C. & H. R. R. R., 1012 Grand Central Terminal, New York City.	Feb. 5, 1908
CHANDLER, ELWYN FRANCIS. Prof. of Math., in Chg. of Civ. Eng., Univ. of North Dakota, University, N. Dak.	Feb. 1, 1910
CHAPMAN, HARRY DAY. City Engr. and Supt. of Streets, Richmond, Cal.	Oct. 7, 1908
CHAPMAN, PAUL. 1546 Minford Pl., Bronx, New York City	June 6, 1906
CHAPPELL, CLAUDE EDWARD. Res. Engr. on Constr. of Pumping Station and Filters, Clarksville, Tenn. (*Jun., Sept. 1, 1908*)	Sept. 6, 1910
CHARLES, LA VERN JOHN. Asst. Engr., U. S. Reclamation Service; Asst. Constr. Engr., Eagle Dam, Elephant Butte, N. Mex.	Oct. 7, 1908
CHARLSWORTH, WILLIAM SAXON. County Engr., Le Karaka, Poverty Bay, New Zealand	Nov. 1, 1899
CHARNLEY, WALTER. 707 Nevin Ave., Sewickley, Pa.	May 4, 1909
CHASE, FRANK DAVID. Archt., Western Elec. Co., Hawthorne Station, Chicago, Ill.	June 30, 1910
CHASE, RICHARD DAVENPORT. 59 Fourth St., New Bedford, Mass. (*Jun., Oct. 5, 1897*)	Oct. 3, 1900
CHASE, RUSSELL. Prin. Asst. Engr., O. W. R. & N. Co., 1209 Wells Fargo Bldg., Portland, Ore.	Feb. 1, 1905
CHASE, WILLIAM HENRY. 162 Allen St., New Bedford, Mass.	April 3, 1907
CHASSAING, CHARLES WILLIS. Care, Selden-Breck Constr. Co., Fullerton Bldg., St. Louis, Mo.	Sept. 6, 1910
CHESTER, CHARLIE ELLSWORTH. Civ. Engr. and Mgr. of Water Co., Shelbyville, Ill.	May 4, 1898
CHIBA, TOSHITOMO. Care, Mr. Narisawa, 5 Kitajimacho 2 Chome, Nihonbashiku, Tokyo, Japan. (*Jun., Mar. 31, 1908*)	Sept. 6, 1910
CHIPMAN, PAUL. Contr. Engr., Osceola, Ark.	Oct. 2, 1907
CHRISTIE, HANS LANGSTED. Care, Bridge Dept., Am. Bridge Co., Ambridge, Pa.	Feb. 28, 1911
CHURCH, HARTLEY ROBERT. 3031 Benvenue Ave., Berkeley, Cal.	June 6, 1911
CHURCHILL, PERCIVAL MITCHELL. Cons. Engr., Boston, Mass.	June 1, 1904
CILLEY, MORGAN. Care, The Troy Wagon Works Co., Troy, Ohio.	Nov. 8, 1909
CLACK, JAMES MORGAN. City Engr., Nevada, Mo.	Oct. 31, 1911
CLAFLIN, FRED WINSLOW. Res. Engr. and Supt. of Constr., Quemahoning Dam, R. F. D. No. 1, Holsopple, Pa.	June 6, 1911
CLAPP, FRANK LEMUEL. Asst. Engr., Board of Water Supply of the City of New York, Cornwall-on-Hudson, N. Y.	May 4, 1909

	Date of Membership
Clapp, George Hubbard. Pres., Pittsburgh Testing Laboratory, Cor. 7th and Bedford Aves., Pittsburgh, Pa	July 1, 1891
Clapp, Sidney Kingman. Asst. Engr., Board of Water Supply, West Shokan, N. Y	April 5, 1905
Clapp, Wilfred Atherton. Civ. Engr. and Supt. of Constr., Quartermaster's Dept., U. S. A., Fort McDowell, Cal	April 4, 1906
Clark, Arthur Edward. Asst. Engr., Public Service Comm., First Dist., 103 East 125th St., New York City	Oct. 4, 1910
Clark, Arthur Pierson. Asst. Mgr. of Sales, Corrugated Bar Co., 402 Mutual Life Bldg., Buffalo, N. Y	Dec. 6, 1910
Clark, Edwin. Structural Engr. and Chf. of the Bureau of Bldg. Inspection, Room 313, City Hall, Philadelphia, Pa	Jan. 6, 1897
Clark, LeRoy Walter. Asst. in Rational and Tech. Mechanics, Rensselaer Polytechnic Inst., 2003 Fifteenth St., Troy, N. Y. (*Jun., Sept. 4, 1906*)	April 4, 1911
Clark, Warren Vester. 1018 Hearst Bldg., San Francisco, Cal	Mar. 7, 1906
Clarke, Elwyn Lorenzo. Civ. and Hydr. Engr., 99 Mountainview Terrace, Sheridan, Wyo	April 1, 1908
Clarke, William Dexter. (Hegardt & Clarke), 1010 Board of Trade Bldg., Portland, Ore	July 10, 1907
Class, Charles Frank. Asst. Engr., Am. Coke & Gas Constr. Co. (Res., 1468 Kenwood Ave.), Camden, N. J. (*Jun., Mar. 3, 1903*)	April 4, 1906
Clausen, Jacob Centennial. Engr. of Sewer Constr. and Maintenance, 2063 West 28th St., Los Angeles, Cal	Sept. 6, 1905
Clawiter, Edward Ivan. Engr. in Chg., Trussed Concrete Steel Co. for South America, Calle Sarmiento 1676, Casilla 191, Buenos Aires, Argentine Republic	June 30, 1911
Claybaugh, Harry Wray. Div. Engr., Penn. State Highway Dept., Franklin, Pa	June 1, 1909
Cleaver, Pitson Jay. Toledo, Wash. (*Jun., April 4, 1899*)	May 1, 1907
Cleveland, Henry Burdett. Prin. Asst. Engr., New York State Dept. of Health, Albany, N. Y	May 31, 1910
Clifford, Reginald George. Res. Engr., Pacific Gas & Elec. Co., 445 Sutter St., San Francisco, Cal	June 30, 1911
Clinton, Samuel Dexter. Box 230, Twin Falls, Idaho	Oct. 5, 1909
Closson, Edgar Stone. Asst. Engr., Public Service Comm., First Dist., 1047 East 10th St., Brooklyn, N. Y. (*Jun., Sept. 4, 1906*)	May 2, 1911
Coates, Frank Raymond. Vice-Pres., Inter-Ocean Steel Co., 217 Railway Exchange, Chicago, Ill	Jan. 3, 1900
Cobb, Stephen Prentis. Supt., Gas Dept., Albany Southern R. R., Albany, N. Y	Mar. 4, 1908
Coe, Robert. With Carnegie Steel Co., 1317 Spruce St., Philadelphia, Pa	Sept. 6, 1910
Cohen, Charles. Engr. for Am. Real Estate Co., 989 Southern Boulevard, Bronx, New York City	Mar. 6, 1907
Cokefair, Francis Albertson. Cons. Engr., Great Northern Power Co., and Chf. Engr. and Vice-Pres., Great Northern Development Co., 309 Providence Bldg., Duluth, Minn	April 6, 1904
Cole, Burt. Porterville, Cal	Jan. 2, 1901
Cole, Clinton Llewellyn. With The H. Wales Lines Co. (Res., 94 Linsley Ave.), Meriden, Conn	May 6, 1908
Cole, Edward Smith. Hydr. Engr., 220 Broadway, New York City	Sept. 7, 1904
Cole, Herbert Nichols. Constr. Engr., Semet Solvay Co., Syracuse, N. Y	Jan. 6, 1904
Cole, Osman Fred. Vice-Pres. of the Dunlap Eng. Operating Co., 535 Marquette Bldg., Chicago, Ill	Sept. 2, 1908
Coleman, Henry Fitch. 404 Seventh St., Logansport, Ind	Mar. 6, 1895
Collar, William Franklin. Supt., The Foundation Co., Deerwood, Minn. (*Jun., April 6, 1909*)	Jan. 3, 1911
Collier, William Neville. Supt. of Constr., U. S. Public Bldgs., North Yakima, Wash	May 2, 1911
Collins, Charles Edwin. Cons. Engr., 321 Drexel Bldg., Philadelphia, Pa.	Mar. 2, 1904
Collins, Clarke Peleg. Civ. and Min. Engr., 809 Johnstown Trust Bldg., Johnstown, Pa	June 4, 1902
Collins, Francis Winfield. Hartsdale, N. Y. (*Jun., Jan. 2, 1906*)	Sept. 6, 1910
Collins, Frank David. Engr., St. Louis Plant, Am. Bridge Co., St. Louis, Mo.	Oct. 7, 1908
Collins, Frank Joseph. Supt. for James Stewart & Co., 284 Alexander St., Rochester, N. Y	Nov. 8, 1909
Collins, George James Schilling. Bee Bldg., Omaha, Nebr	June 5, 1907
Collins, John T. Puerto Plata, Santo Domingo	May 1, 1907
Collins, Stewart Garfield. 705 Sellwood Bldg., Duluth, Minn	Nov. 1, 1910
Collins, Thomas Edward. Asst. Engr., Revaluation of Railroads and Canals, State of New Jersey, Trenton, N. J	June 6, 1911
Collins, Wales Smith. Res. Engr., James A. Green & Co., Inc., Brogan, Ore.	Feb. 28, 1911
Colman, William Tucker. Engr., Lincoln Park, 665 Barry Ave., Chicago, Ill.	Dec. 5, 1911

	Date of Membership
Colnon, Redmond Stephen. Gen. Contr. (Fruin & Colnon), 615 Laclede Bldg., St. Louis, Mo	July 9, 1906
Coltman, Robert, Jr. 112 The Wellington, Washington, D. C	Oct. 4, 1910
Colvin, Donald Dean. Engr., M. of W., National Railroads of Mexico, City of Mexico, Mexico	May 6, 1908
Comstock, Arthur Francis. 72 Altruria St., Buffalo, N. Y	April 4, 1911
Comstock, Harold Dearborn. Asst. Engr., U. S. Reclamation Service, Pathfinder, Wyo	April 5, 1910
Conger, Alger Adams. Hydr. Engr., Power Constr. Co., Shelburne Falls, Mass.	Oct. 1, 1902
Conkling, Leon De Vere. Associate Prof. of Civ. Eng., Lehigh Univ., South Bethlehem, Pa	Dec. 4, 1901
Conley, Clyde Greyson. Contr. Engr., The Mt. Vernon Bridge Co., Mt. Vernon, Ohio	Aug. 31, 1909
Connell, Henry Leo. Asst. Engr., Board of Water Supply, New York City	Jan. 4, 1910
Connell, William Henry. Deputy Commr. of Public Works, Borough of the Bronx, 201st St., near Perry Ave., Bronx, New York City	April 4, 1911
Conner, Arthur Watson. Engr. of Grade Crossings, New York State Barge Canal, Albany (Res., Delmar), N. Y	Jan. 2, 1912
Conner, Ralph Melvin. Engr., U. S. Reclamation Service, Helena, Mont. (*Jun., May 1, 1906*)	Aug. 31, 1909
Conrad, Lowell Edwin. Prof. of Civ. Eng., Kansas State Agri. Coll., Manhattan, Kans	Oct. 3, 1906
Converse, William Hasson. Pres., Converse Bridge Co., Chattanooga, Tenn	Jan. 6, 1892
Conway, John Sebastian. Chf. Const. Engr., Bureau of Light-Houses, Washington, D. C	May 4, 1909
Conzelman, John Edward. Chf. Engr., Unit Constr. Co., Liggett Bldg., St. Louis, Mo	April 4, 1906
Cook, Horace Arthur. Cons. and Const. Engr., 34 West Adams St., Phœnix, Ariz	May 8, 1910
Cook, Paul Darwin. Y. M. C. A., Sioux City, Iowa	Jan. 31, 1911
Cooke, Frederick Hosmer. Culebra, Canal Zone, Panama	July 9, 1906
Cooke, George Richardson. 1109 Ford Bldg., Detroit, Mich	June 3, 1908
Cooke, Saint George Henry. Witherspoon Bldg., Philadelphia (Res., 608 Morton Ave., Ridley Park), Pa	Jan. 5, 1909
Cookinham, Richard Sherman. Twin Falls, Idaho	June 30, 1911
Coomer, Ross Miller. 404 North Sheridan St., Bay City, Mich	Nov. 4, 1908
Cooper, David Reginald. Prin. Asst. to Chf. Engr., Erie Constr. Co., P. O. Box 3, Niagara Falls, N. Y	July 1, 1908
Cooper, Kenneth Farra. Mgr., Am. Cyanamid Co., Niagara Falls, Ont., Canada. (*Jun., Oct. 6, 1903*)	Jan. 8, 1908
Cooper, Ray De Forest. Burns, Ore	April 4, 1911
Cope, Erle Long. 2709 Derby St., Berkeley, Cal. (*Jun., Jan. 7, 1908*)	Dec. 6, 1910
Copeland, Frederick Lucius. Asst. Supt., Bates & Rogers Cons. Co., 885 Old Colony Bldg., Chicago, Ill. (*Jun., Nov. 5, 1907*)	Jan. 31, 1911
Copland, Alexander Chisholm. Asst. Engr., C. & O. Ry., General Offices, Richmond, Va	Mar. 2, 1909
Copley, George Noble. Treas., Goedhart & Bates; Secy. and Treas., U. S. Eng. Co., 324 Security Bldg., Galveston, Tex. (*Jun., April 3, 1906*)	Oct. 5, 1909
Corey, Ray Howard. Pacific Power & Light Co., Spalding Bldg., Portland, Ore	Oct. 3, 1906
Corlett, Bertram Edwin. 612 West McGraw St., Seattle, Wash	May 4, 1909
Cornell, Douglas. Structural Engr. and Acting Commr., Bureau of Bldgs., Dept. of Public Works, Buffalo, N. Y	Sept. 6, 1899
Cornell, John Wesley. Asst. Div. Engr. of Tunnels and Subways for Board of Superv. Engrs., 181 La Salle St., Room 1101, Chicago, Ill.	June 30, 1910
Corning, Dudley Tibbits. 236 Fayette St., Westmont, Johnstown, Pa	Oct. 1, 1902
Corrigan, George Washington. Roadmaster, S. P. Co., Klamath Falls, Ore. (*Jun., Feb. 5, 1901*)	Oct. 5, 1904
Cortelyou, Spencer Van Zandt. Office Engr., Los Angeles County Highway Comm. (Res. 365 East Ave., 52), Los Angeles, Cal	April 4, 1911
Corti, Joseph James. Casilla Correa 68, Mendoza, Argentine Republic	Jan. 1, 1896
Cory, William Earle. 1510 Franklin St., Boise, Idaho	Jan. 2, 1912
Cother, Albert Adiel. 908 C. & N. W. Gen. Office Bldg., Chicago, Ill.	April 1, 1908
Cotton, Frank. Corozal, Canal Zone, Panama	Jan. 31, 1911
Couchot, George John. Care, City Engr.'s Office, San Francisco, Cal	May 3, 1910
Coulson, Benjamin LeFevre. Prof. of Eng., Univ. of the South, Sewanee, Tenn	May 6, 1908
Coulter, Waldo Scarlette. Asst. Engr., Public Service Comm., First Dist., 1117 Glenwood Rd., Brooklyn, N. Y	May 6, 1908
Covell, Vernon Royce. Deputy County Engr., Room 308, Court House, Pittsburgh, Pa	Mar. 7, 1906
Covert, Clermont C. Dist. Engr., U. S. Geological Survey, Room 18, Federal Bldg., Albany, N. Y	July 1, 1909

	Date of Membership
Cowan, Henry Edwin. 118 Mt. Vernon St., Boston, Mass.	Feb. 28, 1911
Cowie, Harry James. Chf. Draftsman, The Niagara Falls Power Co. and Canadian Niagara Power Co., Niagara Falls, N. Y.	Feb. 28, 1911
Cowles, Luzerne Simeon. Asst. Designing Engr., Elev. and Subway Constr., Boston Elev. Ry., 101 Milk St., Boston, Mass.	May 1, 1907
Cowper, John Whitfield. Vice-Pres., Lackawanna Bridge Co., 2 Rector St., New York City. (*Jun., June 21, 1894*)	Oct. 2, 1901
Cox, Charles Barrows. Box 127, Mabton, Wash.	Sept. 6, 1910
Cox, Henry John. Prin. Asst. Engr., Iberia, St. Mary & Eastern R. R., Masonic Bldg., New Iberia, La.	May 2, 1911
Coy, Burgis Greenacre. Res. Engr., The Laramie-Poudre Reservoirs & Irrig. Co., Fort Collins, Colo.	April 4, 1911
Coyne, Harry Lewis. Asst. Engr., Public Service Comm. for First Dist.; 550 West 170th St., New York City. (*Jun., Feb. 5, 1907*)	June 30, 1910
Craig, George Washington. City Engr., Omaha, Nebr.	Feb. 7, 1906
Craig, Joseph Edwin. City Engr., Tallahassee, Fla.	Nov. 8, 1909
Craig, Philip Insley. Flemington, N. J.	Feb. 3, 1904
Craig, Washington Righter. Chf. Engr. and Acting Gen. Supt., Shawmut Min. Co., St. Marys, Pa. (*Jun., May 1, 1894*)	Oct. 1, 1902
Crain, Arthur Manchester. Secy. and Treas., Gate City Constr. Co., 805 Brandeis Theatre Bldg., Omaha, Nebr. (*Jun., Jan. 3, 1907*)	Dec. 1, 1908
Crane, Joseph Spencer. (Kitchell & Crane), 142 Market St., Newark, N. J. (*Jun., Dec. 5, 1905*)	Nov. 4, 1908
Crary, Alexander Patton. Bridge Engr., Republic of Panama, University Club, Ancon, Canal Zone, Panama	June 30, 1911
Crawford, Charles John. Care, S. Pearson & Son, Ltd., Minatitlan, V. C., Mexico	Jan. 31, 1911
Crawley, Ernest Willard. U. S. Junior Engr., 407 First National Bank Bldg. (Res. 299 Norton St.), New Haven, Conn. (*Jun., May 31, 1904*).	Sept. 6, 1910
Creelman, Charles Lauder. 407 National Bank of Commerce Bldg., Tacoma, Wash.	Mar. 4, 1908
Crisp, Ernest John. 1212 Middle Ave., Elyria, Ohio. (*Jun., Oct. 31, 1905*)	April 1, 1908
Crocker, James Roger. Cons. Engr., Warner Chemical Co. and Keystone Chemical Mfg. Co., 202 West 79th St., New York City	June 6, 1911
Cromwell, George. 530 Washington St., San Diego, Cal.	Oct. 3, 1911
Crook, John Anthony. Proprietor, Monarch Eng. Co.; Pres., Monarch Constr. Co., Falls City, Nebr. (*Jun., Feb. 3, 1903*)	Dec. 1, 1908
Crooks, Clinton Hervey. Asst. Engr., Rapid Transit Subway Constr. Co. (Res., 204 West 94th St.), New York City. (*Jun., Oct. 3, 1905*)	Sept. 5, 1911
Crosby, Hewitt. With Atlantic, Gulf & Pacific Co., Park Row Bldg., New York City	Oct. 5, 1909
Crosett, James Haven. Engr. and Gen. Mgr., Visalia Elec. R. R., P. O. Box D, Exeter, Cal.	Jan. 4, 1905
Cross, John Halsey. Care, Am. Bridge Co., Gary, Ind.	Sept. 5, 1911
Crow, Edward. Eng. School, Wanganui, New Zealand. (*Jun., Oct. 3, 1905*)	June 30, 1910
Crowe, Francis Trenholm. Engr., U. S. Reclamation Service, Boise, Idaho.	May 3, 1910
Cryder, Howard Michael. Vice-Pres., Wm. P. Carmichael Co., Engrs. and Contrs., Liggett Bldg., St. Louis, Mo.	June 6, 1906
Crysler, Arthur Garfield. Asst. Engr. on Barge Canal Work, 126 Shonnard St., Syracuse, N. Y.	Aug. 31, 1909
Cudworth, Frank Grant. Cons. Engr. and Archt., 601 Kansas City Life Bldg., Kansas City, Mo.	Jan. 3, 1900
Culgin, Guy Whitmore. Asst. Engr., Bureau of Bldgs., 220 Fourth Ave. (Res., 410 West 148th St.), New York City. (*Jun., Mar. 6, 1900*)	Sept. 7, 1904
Cummings, Noah. Asst. Engr., Dept. of Bridges, City of New York, 316 West 95th St., New York City. (*Jun., Mar. 3, 1896*)	Jan. 6, 1904
Cunningham, Edward Walter. The Eastman, Detroit St., Cleveland, Ohio.	Oct. 2, 1907
Cunningham, John Earl. Am. Felt Co., 246 Summer St. (Res., 2 Louisburg Sq.), Boston, Mass. (*Jun., Sept. 5, 1905*)	Jan. 2, 1912
Cunningham, John George Lawrence. Cons. Engr., Plaza Zaragoza No. 2, Monterey, N. L., Mexico	Jan. 5, 1909
Cunningham, Stanley, Jr. Engr. for Edward Burnett & Alfred Hopkins, 11 East 24th St., New York City	Oct. 3, 1906
Curfman, Lawrence Everett. City Engr., 310 West Rose Ave., Pittsburg, Kans.	Dec. 6, 1910
Currier, Albert Moore. Office Engr., Constr. Dept., L. S. & M. S. Ry., 7711 Lexington Ave., Cleveland, Ohio	May 3, 1910
Curtis, Clinton Alonzo. Asst. Engr., Dept., State Engr. and Surv., in Chg., Contract No. 54, Fort Edward, N. Y. (*Jun., Oct. 1, 1907*)	Oct. 5, 1909
Cushing, Bruce Lincoln. Structural Engr., 1118 Niagara Ave., Niagara Falls, N. Y.	Oct. 4, 1910
Cutler, Alvin Sayles. Asst. Prof. of Ry. Eng., Univ. of Minnesota, Minneapolis, Minn.	Feb. 1, 1910
Cutting, George Warren, Jr. Civ. and Hydr. Engr., 6 Beacon St., Boston, Mass.	May 3, 1910

	Date of Membership
Daae, Hans Andreas. Contr. Engr., Clark & Henery Constr. Co., 515 Ochsner Bldg., Sacramento, Cal.	June 30, 1911
Daggett, Fred Wallis. 1010 Paddock Bldg., Boston, Mass.	May 1, 1907
Dahlin, John Edward Bartholomew. Engr., Bridge Dept., C. & N. W. Ry., Chicago (Res., The Ridgewood Bldg., Edison Park), Ill.	Oct. 31, 1911
Dalrymple, Francis Wharton. Care, Guerber, Lavis & Co., 50 Church St., New York City	Feb. 7, 1894
Daly, David Augustus. Care, P. T. Walsh, Port Arthur, Ont., Canada	May 31, 1910
Dambach, William Nicholas. Junior Engr., U. S. Engr. Office, Wheeling, W. Va.	Sept. 6, 1910
Daniels, Mark Roy. Civ. and Hydr. Engr., 517 Monadnock Bldg., San Francisco, Cal.	Nov. 4, 1908
Daniels, Thomas Remington Holden. Engr., Birmingham Ry., Light & Power Co., Birmingham, Ala.	Feb. 6, 1907
Dann, Alexander William. Box 404, Vicksburg, Miss. *(Jun., Feb. 4, 1908)*	Dec. 5, 1911
Darling, John Whitson. Asst. Engr., N. Y. C. & H. R. R. R., 145 Washington St., Buffalo, N. Y.	June 7, 1905
Darrow, Marius Schoonmaker. Supt., The Barber Asphalt Paving Co., Maurer, N. J. *(Jun., Feb. 6, 1900)*	Dec. 1, 1908
Darrow, Wilton Joseph. Cons. Engr. (Balcom & Darrow), 70 East 45th St., New York City	Nov. 1, 1905
Darwin, Walton Pruett. Commr. of Bldgs., Jacksonville, Fla.	Feb. 6, 1907
Dater, Philip Herrick. Res. Engr., Barge Canal, Little Falls, N. Y.	April 5, 1905
Datz, Louis Christian William. Engr., M. of W., New Orleans Ry. & Light Co., 323 Baronne St., New Orleans, La.	June 30, 1911
Daugherty, Henry Michael. Constr. Supt., J. G. White & Co., Inc., Alaska Commercial Bldg., San Francisco, Cal.	May 6, 1908
Davenport, James Watson. Chf. Engr., The Bonhomie Southwestern R. R., Hattiesburg, Miss.	Nov. 30, 1909
Davies, John Percival. 529 West 111th St., New York City	May 2, 1911
Davies, William Gomer. Willows, Cal. *(Jun., Feb. 2, 1904)*	Nov. 8, 1909
Davis, Benjamin Herman. Cons. Engr., Metropolitan Bldg., New York City	Nov. 30, 1909
Davis, Charles Moss. 217 Fort Worth National Bank Bldg., Fort Worth, Tex. *(Jun., Jan. 3, 1907)*	Oct. 3, 1911
Davis, Edson Joseph. Brown, Cal.	Oct. 3, 1911
Davis, Fred Carnot. Civ. and Hydr. Engr. (Pratt & Davis), 117 Main St., Fitchburg, Mass.	Oct. 7, 1908
Davis, Fred Rufus. Insp., Associated Factory Mutual Fire Ins. Cos., 810 Denckla Bldg., Philadelphia, Pa.	Nov. 5, 1902
Davis, Frederick. Supt., Santa Cruz Portland Cement Co., Davenport, Cal.	Oct. 4, 1905
Davis, George Jacob, Jr. Asst. Prof. of Hydr. Eng., Univ. of Wisconsin, 1731 Regent St., Madison, Wis. *(Jun., Nov. 4, 1902)*	Oct. 2, 1907
Davis, George Robert. Topographic Engr., U. S. Geological Survey, Washington, D. C.	April 3, 1907
Davis, Gilbert Louis. Care, U. S. Reclamation Service, Helena, Mont.	Mar. 4, 1908
Davis, Harold. Union Trust Bldg, Washington, D. C.	Oct. 2, 1901
Davis, James Lyford. Asst. Engr., Board of Water Supply, City of New York, Bryn Mawr Park, Yonkers, N. Y.	May 4, 1904
Davis, John Charles. Dean of Coll. of Applied Science and Eng., Marquette Univ., Milwaukee, Wis.	July 1, 1909
Davis, William Russell. Chf. Bridge Designer and Insp., Office of State Engr. of New York, 6th Floor, De Graaf Bldg., Albany, N. Y.	May 2, 1900
Davoud, Vahram Yettvart. Elec. and Mech. Engr., Telluride Power Co., Provo, Utah	July 1, 1909
Dawson, Jay Bosworth. Box 51, Station C, Los Angeles, Cal.	June 30, 1910
Day, Edward Bliss. Pres., Federal Lumber Co., Blaine, Wash.	Feb. 4, 1903
Day, Warren French. Vice-Pres., Jas. A. Green & Co., Inc., 509 Overland Bldg., Boise, Idaho	Dec. 6, 1910
Day, William Peyton. Sheldon Bldg., San Francisco, Cal. *(Jun., Mar. 6, 1906)*	Mar. 1, 1910
Deacon, Ernest Franklin. Chf. Engr., Va. South. R. R., Abingdon, Va.	July 10, 1907
Dean, Stanley. Instr. in Civ. Eng., Armour Inst. of Tech. (Res., 6940 Wentworth Ave.), Chicago, Ill.	April 1, 1908
DeBerard, Wilford Willis. Western Editor, *Engineering Record,* 1570 Old Colony Bldg., Chicago, Ill.	May 2, 1906
Decker, John Hull. Chf. Engr. and Gen. Mgr., Atlantic Constr. & Supply Co., 232 Bartlett Bldg., Atlantic City, N. J. *(Jun., Sept. 6, 1904)*	Dec. 5, 1906
DeGraff, Harry Westbrook. Field Supt., Am. Pipe & Const. Co., 20 Market St., Amsterdam, N. Y.	Jan. 3, 1906
de Gratresse, Joseph Reygondeau. Hawkesbury, Ont., Canada	Jan. 2, 1907
De La Mater, Stephen Truesdell. Chf. Estimator, Jas. Stewart & Co., 30 Church St., New York City	Nov. 4, 1908
Demorest, George Myron. Care, Am. Bridge Co., Frick Bldg., Pittsburgh, Pa.	June 30, 1910

	Date of Membership
DeMott, Charles Leonard. 47 Law Bldg., Lynchburg, Va	June 6, 1906
Dempster, Osborne Joel. City Engr., Little Falls, N. Y	Jan. 3, 1906
Dennis, Harry Whiting. Constr. Engr., Southern California Edison Co., Los Angeles, Cal	Oct. 2, 1907
Dent, Elliott Johnstone. Capt., Corps of Engrs., U. S. A., Vancouver Barracks, Vancouver, Wash	May 1, 1907
Dent, Walter Devere. Care, J. E. Sirrine, Greenville, S. C	Nov. 8, 1909
Derby, Chester Cawthorne. Structural Engr., 15 Ashmont St., Portland, Me	May 4, 1909
Derr, Homer Munro. Prof. of Civ. Eng., South Dakota State Coll., Brookings, S. Dak	Jan. 4, 1910
Derrick, Clarence. Estimating Dept., Berlin Constr. Co., Berlin (Res., 130 Black Rock Ave., New Britain), Conn	Oct. 4, 1910
Dessery, Floyd Gossett. 1117 Union Trust Bldg., Los Angeles, Cal	Feb. 28, 1911
Devlin, Henry Stratford. Office, Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City (Res., 349 Clinton St., Brooklyn, N. Y.)	June 5, 1907
de Vou, James Laird. Asst. Mgr., Pittsburgh Div., Erecting Dept., Am. Bridge Co. of N. Y., Frick Bldg., Pittsburgh, Pa	April 1, 1903
De Weese, Bernard Dall. (B. D. De Weese & Co.), 223 Century Bldg., Denver, Colo	May 2, 1911
Dewell, Henry Dievendorf. Asst. Engr., Galloway & Markwart, 723 First National Bank Bldg., San Francisco, Cal	May 2, 1911
Diamant, Arthur Herbert. Cons. Engr., 206 Granite Bldg., St. Louis, Mo. (*Jun., May 5, 1903*)	Dec. 5, 1906
Dicke, Edward Christian. 3639 Humphrys St., St. Louis, Mo. (*Jun., May 3, 1904*)	April 6, 1909
Dickerson, John Thomas. Asst. Engr., Sales Dept., Scherzer Rolling Lift Bridge Co., 1616 Monadnock Bldg., Chicago, Ill	April 5, 1910
Dickinson, William Dewoody. (Dickinson & Watkins), State Bank Bldg., Little Rock, Ark	May 3, 1910
Dieden, Gotthard Vincent. Cons. Engr., 47 Stortorget, Malmo, Sweden	Oct. 2, 1907
Diehl, David Leslie. Secy. and Treas., The Lewisburg, Milton & Watsontown Passenger Ry; (Whittaker & Diehl and Ferro Concrete Co.), Harrisburg, Pa	Jan. 5, 1909
Dietrich, William Henry. Res. Engr., U. S. Steel Products Co., 24^{a} Kiangse Rd., Shanghai, China	Jan. 4, 1910
Digby, Joseph Herbert. Care, Madeira-Mamoré Ry., Itacoatiara, Amazonas, Brazil	Oct. 3, 1911
Dilks, Lorenzo Carlisle. Contr. Mgr., The Eastern Steel Co., 60 Broadway, New York City	Jan. 3, 1906
Dillard, John Lea. Gen. Mgr., The Sturm & Dillard Co., Contrs., 408 Summit St., Winston-Salem, N. C	June 1, 1904
Dillon, Francis Henry. P. O. Box 454, San Antonio, Tex	Oct. 3, 1900
Dingle, James Hervey. City Engr., Charleston, S. C. (*Jun., April 30, 1895*)	Oct. 4, 1899
Dixon, De Forest Halstèd. Second Vice-Pres., Turner Constr. Co., 11 Broadway, New York City (Res., 169 Columbia Heights, Brooklyn, N. Y.). (*Jun., May 3, 1898*)	Feb. 3, 1904
Dobson, Gilbert Colfax. With Isthmian Canal Comm., Gatun, Canal Zone, Panama	May 2, 1911
Dodd, John Hugh. Jamaica Govt. Ry., Kingston, Jamaica	Mar. 6, 1907
Dodge, Mott V. Civ. and Hydr. Engr. (Cooper & Dodge), Burns, Ore	April 4, 1911
Dodge, Samuel Douglass. Asst. Engr., Board of Water Supply of City of New York, Cornwall-on-Hudson, N. Y	Nov. 6, 1907
Doebler, Valentine Sherman. Supt., Transportation, Cam. Steel Co., Johnstown, Pa	Dec. 6, 1893
Donahey, Joseph Alexander. Asst. Engr., A., C. & Y. Ry., Everett Bldg., Akron, Ohio	Dec. 4, 1907
Donovan, Daniel Bartholomew. Res. Engr., Barge Canal, Rome, N. Y	Nov. 8, 1909
Doolittle, Harold James. Engr. and Contr., 313 North Naches, North Yakima, Wash	June 6, 1911
Dorrance, William Tully. Dist. Engr., N. Y. C. & H. R. R. R., Union Station, Albany, N. Y	Sept. 4, 1901
Dorsey, Leander. Supt., Whiting-Turner Constr. Co., Sexton Bldg., Baltimore, Md	Oct. 4, 1905
Dorsey, William Henry. Engr. and Mgr., Sanford & Brooks Co., 24 Commerce St., Baltimore, Md	June 5, 1907
Doten, Leonard Smith. Civ. Engr., War Dept. (Res., 410 A St., N. E.), Washington, D. C	July 9, 1906
Doty, John Williams. With The Foundation Co., 115 Broadway, New York City. (*Jun., Nov. 3, 1903*)	Jan. 4, 1905
Dougan, James. Engr. with Clinton & Russell, 32 Liberty St., New York City. (*Jun., Mar. 5, 1901*)	Mar. 2, 1904
Dow, William Grear. 222 South Grant Ave., Denver, Colo	Dec. 6, 1910
Downer, Thomas Benson. 100 South Monterey St., Alhambra, Cal	Oct. 2, 1907

	Date of Membership
Downes, Alfred Kimball. Engr. and Contr., Lunenburg Bank Bldg., Kenbridge, Va	Feb. 3, 1904
Downman, Julian Romney. 2022 N St., N. W., Washington, D. C	Dec. 4, 1901
Doying, William Albert Edward. Insp. Engr., Isthmian Canal Comm. (Res., 3525 Fourteenth St., N. W.), Washington, D. C	Feb. 1, 1910
Doyle, Edmund Henry. City Engr., Miami, Okla	Nov. 1, 1910
Doyle, Henry Sisson. Gen. Mgr., Reinforced Concrete Dept., Am. Steel & Wire Co., Chicago, Ill	Jan. 8, 1908
Drake, Robert Morris. Dist. Engr., S. P. Co., Room 1052, Flood Bldg., San Francisco, Cal	Mar. 7, 1900
Drane, Brent Skinner. 1118 Realty Bldg., Charlotte, N. C	July 10, 1907
Drew, Charles Davis. With J. G. White & Co., Ltd., 9 Cloak Lane, London, E. C., England	Oct. 7, 1903
Drowne, Henry Bernardin. Instr. in Highway Eng., Columbia Univ.; Prin. Asst. Engr. with Arthur H. Blanchard, 210 Hartley Hall, Columbia Univ., New York City. (*Jun., Sept. 5, 1905*)	Mar. 4, 1908
Du Bois, Julian. 318 Allen St., Hudson, N. Y	Jan. 8, 1902
Duder, John. Deputy City Engr., 125 M St., Salt Lake City, Utah	Nov. 8, 1909
Dufour, Frank Oliver. Asst. Prof. of Structural Eng., Univ. of Illinois, Urbana, Ill. (*Jun., Dec. 5, 1899*)	Oct. 1, 1902
Duncan, Dorsey Berry. 1305 Windsor St., Columbia, Mo	May 31, 1910
Duncan, James Harper. Civ. Engr. and Surv., Searsport, Me. (*Jun., Dec. 4, 1906*)	Feb. 1, 1910
Dunglinson, George, Jr. Care, Allotment Commr., N. & W. Ry., Bluefield, W. Va	Nov. 1, 1910
Dunlop, Samuel Campbell. Asst. Engr., Charleston Sewer System, Office, City Engr., Charleston, S. C	Dec. 6, 1910
Dunmire, Elijah Herbert. City Engr., Lawrence, Kans. (*Jun., Mar. 5, 1907*)	Oct. 3, 1911
Dunn, Emmett Clarke. City Engr., Alexandria, Va	Nov. 4, 1891
Dunn, Herbert Luther. With the T. A. Scott Co., Marine Engrs., New London, Conn	Nov. 1, 1905
Dunn, Oswald Thorpe. Asst. Engr., Ill. Cent. R. R., Fulton, Ky	Sept. 6, 1910
Dunn, William Robert. Works Mgr., Vulcanite Portland Cement Co., Phillipsburg, N. J	April 6, 1904
Dunnells, Clifford George. Asst. Prof. of Mechanics, School of Applied Industries, Carnegie Technical Schools, Pittsburgh, Pa. (*Jun., Feb. 4, 1902*)	Jan. 2, 1907
Durant, Aldrich. P. O. Box 1149, Havana, Cuba	Oct. 31, 1911
Dutton, Charles Henry. With J. R. Worcester & Co., Boston, Mass	Jan. 8, 1908
Dygert, Harry Isaiah. 2623 Ashby Ave., South Berkeley, Cal	May 3, 1910

Easterbrooks, Preston Burt. Chf. Asst. Engr., Caribbean Constr. Co., Port-au-Prince, Haiti	May 1, 1907
Ebashi, Teiji. Care, Waddell & Harrington, 1012 Baltimore Ave., Kansas City, Mo	Oct. 4, 1910
Eberly, Clarence Frederick. Topographer, U. S. Geological Survey, Washington, D. C	Sept. 6, 1910
Eddy, Charles Wells. Res. Engr., Waterbury Water Supply, Thomaston, Conn.	Mar. 2, 1909
Edelen, Thomas Jefferson Stone. Suite 28, Preston Court, Winnipeg, Man., Canada	July 1, 1909
Eder, Henry James Cali, Colombia. (*Jun., June 5, 1894*)	Sept. 1, 1897
Edmondson, Ralph Selden. Asst. Engr., Board of Water Supply, City of New York, High Falls, N. Y	June 6, 1911
Edwards, Charles Milton. First Asst. Engr., New York State Dept. of Highways, Kirstein Bldg., Rochester, N. Y	Sept. 2, 1908
Edwards, Dean Gray. Care, Bradley Contr. Co., 4th Ave. and 3d St., Brooklyn, N. Y. (*Jun., Nov. 1, 1904*)	Feb. 1, 1910
Edwards, Frederick. Engr. in Chg., State Reservation Comm. at Saratoga, 369 Congress St., Troy, N. Y. (*Jun., Jan. 31, 1899*)	Feb. 5, 1902
Edwards, Harold. 289 Garry St., Winnipeg, Man., Canada	Sept. 6, 1910
Edwards, Llewellyn Nathaniel. P. O. Box 762, Montreal, Que., Canada.	Mar. 1, 1910
Edwards, Oliver Cromwell, Jr. Pres., The Caisson Co., Johnsonburg, N. J. (*Jun., Oct. 7, 1902*)	Dec. 5, 1906
Edwards, William Watkyn. Chf. Engr., Quesnelle Hydr. Gold Min. Co., Hydraulic, Carriboo Dist., B. C., Canada	Oct. 3, 1911
Egan, Louis Henry. Gen. Mgr., Kansas City Elec. Light Co., 1500 Grand Ave., Kansas City, Mo	Oct. 5, 1909
Egbert, Warren. Colfax, Cal	Nov. 1, 1910
Ehrbar, Louis Harvey. Engr., Subway Constr., Plant Dept., N. Y. Telephone Co., 15 Dey St., New York City	May 2, 1906
Eitzen, Arthur Robert. 23d and Grand Ave., Kansas City, Mo. (*Jun., Sept. 6, 1904*)	Nov. 1, 1910
Elam, William Earle. Asst. Engr., Mississippi Levee Board, Greenville, Miss. (*Jun., Feb. 6, 1906*)	Oct. 31, 1911

	Date of Membership
ELBURY, THOMAS GEORGE. Municipal Engr. and Contr., 552 Pacific Bldg., San Francisco, Cal.	May 6, 1908
ELD, CHARLES JOHN, JR. 3709 Windsor Pl., St. Louis, Mo.	May 6, 1903
ELDER, ERNEST HARTWELL. Pres., Midland Eng. Co., 301 Masonic Temple, North Yakima, Wash.	June 30, 1911
ELDRIDGE, MAURICE OWEN. Care, U. S. Dept. of Agri., Washington, D. C.	April 4, 1911
ELLIOTT, GEORGE ALEXANDER MILLER. Supt., Spring Val. Water Co., 1268 Sacramento St., San Francisco, Cal.	Sept. 5, 1911
ELLIOTT, JOHN STUART. Civ. and Min. Engr., 29 Broadway, New York City.	April 6, 1892
ELLIOTT, MALCOLM. Junior Engr., U. S. Engr. Office, Room 425, Custom House, Louisville, Ky. (*Jun., Nov. 5, 1907*)	April 6, 1909
ELLIS, CHARLES ALTON. Asst. Prof. of Civ. Eng., Univ. of Michigan; Bridge Engr., 916 Church St., Ann Arbor, Mich.	April 3, 1907
ELLIS, GUERNSEY WILLIAM. Structural Engr., Care, Turner Constr. Co., 312 Prudential Bldg., Buffalo, N. Y.	Nov. 4, 1908
ELLSTROM, VICTOR EDWIN. St. Louis Representative and Structural Engr., Bethlehem Steel Co., 1015 Chemical Bldg., St. Louis, Mo.	Dec. 6, 1910
ELLSWORTH, LINCOLN. 18 East 53d St., New York City. (*Jun., May 5, 1908*)	Oct. 3, 1911
ELROD, HENRY EXALL. Gen. Mgr., Union Iron Works, Houston, Tex.	Nov. 7, 1906
ELY, CARL BRANDES. Asst. to Supt., B. and C. Dept., Pennsylvania Steel Co., Steelton, Pa.	April 3, 1907
ELY, GEORGE WELLS, JR. 529 West 186th St., New York City.	Dec. 5, 1911
ELY, JOHN ANDREWS. Care, Brown, Shipley & Co., Pall Mall, London, S. W., England. (*Jun., April 30, 1901*)	Jan. 8, 1908
ELY, JOHN STANTON. Engr. in Chg., Queen Lane Filter Plant, Germantown, Philadelphia, Pa.	Mar. 2, 1904
EMERSON, CHARLES ALVIN, JR. Asst. Engr. in Chg. of Design and Constr., Pennsylvania Dept. of Health, Harrisburg, Pa.	June 30, 1911
EMERSON, GEORGE DANA. Asst. Engr., Boston Transit Comm., 15 Beacon St., Boston, Mass.	June 3, 1908
EMERSON, KENNETH BALES. Asst. Engr. Designer, New York Board of Water Supply, 165 Broadway, New York City.	Oct. 3, 1911
EMERSON, RAFFE. Box 200, Topeka, Kans.	June 30, 1910
ENGLE, CHARLES ALGERNON. Address unknown. (*Jun., May 5, 1908*)	Oct. 5, 1909
ENGSTRÖM, FRANS. City Engr., Altoona, Pa.	May 4, 1892
ENSEY, RICHARD FAHNESTOCK. P. O. Box 515, Fort Lauderdale, Fla.	April 5, 1910
ESPENSHADE, EDWARD BOWMAN. Asst. Engr., The Dolese Shepard Co. (Res., 6354 Greenwood Ave.), Chicago, Ill.	Nov. 6, 1907
ESTES, FRANKLIN EDWARD. Contr. Engr., Box 506, St. Petersburg, Fla.	Feb. 7, 1906
ETCHEVERRY, BERNARD ALFRED. Agri. Bldg., Univ. of California, Berkeley, Cal.	June 1, 1909
EVANS, EDWIN MONTAGUE. Gen. Mgr., The Plowman Const. Co., Mutual Life Bldg., Philadelphia, Pa.	Feb. 28, 1911
EVANS, JOHN EDWARD. Asst. Div. Engr., M. C. R. R., Detroit (Res., 413 Maple St., Ypsilanti), Mich.	Nov. 8, 1909
EVANS, JOHN MAURICE. Treas., Cooper & Evans Co., Gen. Contrs., 220 Broadway, New York City. (*Jun., May 4, 1897*)	Jan. 3, 1900
EVANS, PETER PLATTER. Secy., The Osborn Eng. Co., Cleveland, Ohio. (*Jun., Feb. 6, 1894*)	Mar. 7, 1900
EVERHAM, ARTHUR CASSIDY. Asst. Chf. Engr., Kansas City Terminal Ry., Kansas City, Mo. (*Jun., Feb. 6, 1906*)	June 5, 1907
EWALD, ROBERT FRANKLIN. Asst. Engr., U. S. Reclamation Service, Provo, Utah.	Jan. 3, 1911

FAIN, JAMES RHEA. Supt. of Constr., U. S. Public Bldgs., Harriman, Tenn.	June 4, 1902
FAIRBAIRN, WILLIAM JAMES. Asst. Engr. of Constr., Board of Water Commrs., 274 Commonwealth Ave., Detroit, Mich.	Dec. 5, 1911
FAIRCHILD, JOHN FLETCHER. Engineering Bldg., Mt. Vernon, N. Y. (*Jun., April 5, 1892*)	Dec. 4, 1895
FALCONER, DONALD PATTON. Asst. Engr., M. of W., New York State Rys., 267 State St., Rochester, N. Y.	Oct. 3, 1911
FALTER, PHILIP HENRY. Gen. Supt., Northern Aluminum Co., Ltd., Shawinigan Falls, Que., Canada.	Mar. 7, 1906
FARLEY, WILLIAM SANBORN. Gen. Contr. (Scott & Farley), 48 Bacon Bldg., Oakland, Cal.	Nov. 8, 1909
FARNHAM, ARTHUR BENJAMIN. Engr., Board of Public Works, Pittsfield, Mass.	Jan. 2, 1907
FARNHAM, CHARLES HENRY. 18 Cedar St., Beverly, Mass.	June 1, 1904
FARQUHAR, HENRY STILSON. Gen. Mgr. and Chf. Engr., Phil. & West. Ry., Upper Darby, Pa. (*Jun., April 5, 1892*)	Nov. 4, 1896
FARRIN, JAMES MOORE. Engr. of Bridges and Bldgs., Cuba R. R., Camagüey, Cuba.	Nov. 30, 1909
FARWELL, CARROLL ANDREW. Care, Medina Irrig. Co., Castroville, Tex.	Jan. 31, 1911

	Date of Membership
Federlein, Walter Gottlieb. Asst. Engr., Rapid Transit Subway Constr. Co., 266 West 95th St., New York City. (*Jun., Jan. 2, 1906*)	Feb. 2, 1909
Felgenhauer, Frank John. Contr. Builder and Engr.; Res., 1439 Dean St., Brooklyn, N. Y. (*Jun., May 4, 1909*)	June 30, 1911
Fenkell, Neal Charles. Engr., Smith, Hinchman & Grylls, 228 Baldwin Ave., Detroit, Mich	Dec. 1, 1908
Fenstermaker, DeWitt Clinton. Office Engr., L. & N. E. R. R., Room 30, Navigation Bldg., Mauch Chunk, Pa	Jan. 8, 1908
Fenton, Louis Gillespie. Asst. Engr. Designer, Board of Water Supply, 299 Broadway, New York City	Feb. 1, 1905
Ferguson, Lewis Repp. Cons. Engr., 1526 Land Title Bldg., Philadelphia, Pa. (*Jun., Aug. 31, 1909*)	Jan. 31, 1911
Ferguson, William Hastings. P. O. Box 479, Prince Rupert, B. C., Canada	Jan. 7, 1903
Ferradas, Ramiro. Care, Sociedad de Ingenieros, Lima, Peru. (*Jun., Jan. 3, 1905*)	Mar. 7, 1906
Ferris, Frederick Edward. Asst. Engr., R. T. R. R. Comm., 231 West 125th St., New York City (Res., 820 Montgomery St., Jersey City, N. J.)	June 1, 1898
Fertig, Jerome Henry. Asst. Engr., U. S. Reclamation Service, Montrose, Colo. (*Jun., Oct. 2, 1906*)	Mar. 1, 1910
Fifield, Ralph Herbert. Care, U. S. Reclamation Service, Williston, N. Dak	Feb. 28, 1911
Fineren, William Warrick. Junior U. S. Engr., U. S. Engr. Office, Federal Bldg., Tampa, Fla	Oct. 5, 1909
Firth, Elmer Wallace. Asst. Engr., Bureau of Sewers, Borough of Queens, New York City (Res., 1 John St., Jamaica, N. Y.). (*Jun., Jan. 7, 1896*)	Nov. 7, 1906
Firth, Joseph. City Engr., Charlotte, N. C	June 5, 1907
Fischer, Guillermo Gustavo. Chf. Engr., Public Works of the Provincial Govt., Santa Clara, Cuba. (*Jun., Feb. 2, 1904*)	Dec. 6, 1910
Fischer, Theodore Christian. 535 Adams Ave., Elizabeth, N. J	Dec. 4, 1907
Fisher, Chester Centennial. Asst. Engr., U. S. Reclamation Service, Boise, Idaho. (*Jun., April 3, 1906*)	Oct. 2, 1907
Fisher, Howell Tracy. 5235 Archer St., Germantown, Philadelphia, Pa.	Nov. 1, 1905
Fisher, Wager. Cons. Engr., Commonwealth Trust Bldg., Philadelphia, Pa. (*Jun., Oct. 3, 1899*)	Nov. 6, 1907
Fisher, Wilbur Howard. Res. Engr., City Engr.'s Office, Spokane, Wash. (*Jun., Dec. 6, 1904*)	Nov. 30, 1909
Fisk, Andrew Jackson, Jr. Civ. and Hydr. Engr., Helena, Mont	Nov. 30, 1909
Fisk, Clinton Hinckley. Cons. Engr., 1232 Oakley Pl., St. Louis, Mo	June 5, 1907
Fisk, George Farnsworth. Engr., Bureau of Eng., Dept. of Public Works, Room 7, Municipal Bldg., Buffalo, N. Y	Jan. 3, 1911
Fitch, Squire Earnest. Asst. Engr., Dept. of Highways, Falconer, N. Y	July 9, 1906
Fitzgerald, Walter Lewis. Designing Engr., Sellers & Rippey; Cons. Engr., 1416 Rush St., Philadelphia, Pa	May 3, 1910
Fitzpatrick, James Raymond. Gen. Mgr., Grand Rapids Hydr. Co., 106 Michigan Trust Bldg., Grand Rapids, Mich	May 31, 1910
FitzRandolph, William Sheppard. Builder and Gen. Contr. (Bang & FitzRandolph), 1328 Broadway, New York City. (*Jun., April 3, 1906*)	Sept. 6, 1910
Flaherty, Edward Thomas. Archt. and Engr. (Linthwaite & Flaherty), 539 I. W. Hellman Bldg., Los Angeles, Cal	Feb. 28, 1911
Fleming, Thomas, Jr. Hydr. and San. Engr. (Chester & Fleming), Union Bank Bldg., Pittsburgh, Pa. (*Jun., Nov. 5, 1907*)	Oct. 5, 1909
Fletcher, Josiah Monk. Richmond, Jamaica	Oct. 4, 1905
Floyd, Earl Nesby. Insp., Pittsburgh Testing Laboratory, South Pittsburg, Tenn	Oct. 3, 1911
Focht, Louis. Chf. Engr., State Board of Assessors (Res., 12 Atterbury Ave.), Trenton, N. J	May 4, 1892
Fogg, Percival Morris. Engr., U. S. Reclamation Service, Rupert, Idaho.	Nov. 6, 1907
Follansbee, Robert. Dist. Engr., U. S. Geological Survey, Denver, Colo. (*Jun., Nov. 1, 1904*)	Oct. 7, 1908
Foote, Arthur Burling. Asst. Supt., North Star Mines Co., Grass Valley, Cal	Mar. 1, 1905
Forbes, Murray. Mgr. and Treas., Westmoreland, Irvin, Dennison and Derry Water Companies, Huff Bldg., Greensburg, Pa	June 5, 1907
Forchhammer, Herluf Trolle. Chf. Engr., Christiani & Nielsen Co., Raadhusplads 77, Copenhagen, Denmark	Feb. 1, 1905
Ford, Harry Clifford. Chf. Engr., Rodgers & Hagerty, Gen. Contrs., 417 West 150th St., New York City. (*Jun., Mar. 6, 1906*)	Feb. 1, 1910
Ford, Howard Carlton. Associate Prof. of Civ. Eng., Iowa State Coll., Ames, Iowa. (*Jun., Sept. 1, 1908*)	May 31, 1910
Ford, Robert Henry Persse. Chf. Engr., Hodges-Downey Constr. Co., 336 Pierce Bldg., St. Louis, Mo. (*Jun., Mar. 2, 1897*)	June 7, 1899

	Date of Membership
FORD, WILLIAM ELLIS. (Ford & MacCrea), Room 339, Gazette Bldg., Little Rock, Ark	Mar. 1, 1910
FORREST, CHARLES NEEDHAM. Maurer, N. J	April 6, 1909
FORREST, GEORGE MUNRO. 280 Broadway, Room 259, New York City	Oct. 2, 1907
FORTNEY, CAMDEN PAGE. Supervisor of Machinery Erection, Isthmian Canal Comm., Gatun, Canal Zone, Panama. *(Jun., Oct. 2, 1906)*	Nov. 30, 1909
FOSS, JOHN HARRISON. Instr., Civ. Eng. Dept., Leland Stanford, Jr., Univ., P. O. Box 65, Palo Alto, Cal. *(Jun., Dec. 1, 1903)*	Oct. 4, 1910
FOSTER, MORTIMER. 15 West 38th St., New York City	June 1, 1904
FOSTER, SAMUEL DAVIS. Chf. Engr., Penn. State Highway Dept., Harrisburg, Pa	June 30, 1911
FOUGNER, HERMANN. Civ. Engr. and Agt., Trussed Concrete Steel Co., 25 Madison Sq., North, New York City	Feb. 1, 1905
FOUILHOUX, JACQUES ANDRÉ. Cons. Engr., Whitehouse & Fouilhoux, Archts., Portland, Ore	Oct. 5, 1909
FOUNTAIN, THOMAS LILLY. Civ. and San. Engr., The Fountain-Shaw Eng. Co., Dallas, Tex. *(Jun., April 2, 1907)*	April 6, 1909
FOWLER, FRANK GEORGE. Civ. Engr. and Contr., Mt. Kisco, N. Y	June 5, 1907
FOWLER, FREDERICK HALL. Hydro-Elec. Engr., U. S. Forest Service, First National Bank Bldg., San Francisco (Res., 221 Kingsley Ave., Palo Alto), Cal. *(Jun., April 3, 1906)*	April 4, 1911
FOWLER, ROBERT LAMBERT. Mgr., Barber Asphalt Paving Co., Maurer, N. J	Feb. 2, 1909
FOX, CHARLES LOUIS. Asst. Supt., Pennsylvania Water Co., 701 Wood St., Wilkinsburg, Pa. *(Jun., May 5, 1903)*	May 2, 1911
FOX, HERMAN HENRY. With Waddell & Harrington, 1012 Baltimore Ave., Kansas City, Mo	Sept. 5, 1911
FOYÉ, ANDREW ERNEST. Pres., Andrew E. Foyé Co., 20 Broad St., New York City. *(Jun., May 2, 1893)*	Nov. 4, 1896
FRASQUIERI Y REGUEIFERO, TRANQUILINO. Ingeniero de Caminos, Canales y Puertos, San Lazaro 101, Havana, Cuba	Aug. 31, 1909
FRAZEE, JOHN HATFIELD. 516 West 183d St., New York City	Dec. 6, 1899
FREEMAN, ARTHUR CLARICO, JR. 343 Arcade Bldg., Norfolk, Va	July 1, 1908
FREEMAN, MILTON HARVEY. Asst. Engr., Board of Water Supply, New York City, Stone Ridge, Ulster Co., N. Y	July 1, 1909
FREITAG, JOSEPH KENDALL. Secy. and Treas., A. B. Robbins Iron Co., Norfolk Downs, Quincy, Mass	Jan. 3, 1900
FRENCH, CHAPMAN JOHNSTON. Narrows, Va	Jan. 31, 1911
FRENCH, CHARLES RAUCH. Engr. for Herrick Constr. Co., Wilkes-Barre, Pa	Oct. 7, 1908
FREW, ARCHIBALD JOHN RUSSELL. Engr. in Chg. of Constr. of Sec. of The Chillagoe-Etheredge Ry., Malloy, North Queensland, Australia	Oct. 5, 1909
FREW, ROBERT DICKSON ALISON. Chelmer, near Brisbane, Queensland, Australia	June 1, 1898
FREY, FRANK EDWARD. Engr. and Contr., 820 Georgia St., Vallejo, Cal	Oct. 3, 1906
FRICK, WALTER. Lewisburg, Union Co., Pa	Dec. 2, 1896
FRICKSTAD, WALTER NETTLETON. 1815 Tenth Ave., Oakland, Cal	June 5, 1907
FRINK, FRED GOODRICH. Prof., Railway Eng., Univ. of Oregon, Eugene, Ore	May 3, 1899
FRISELL, ERIC HJALMAR. Contr. Engr., Milliken Bros., Inc., 3544 Broadway, New York City	June 5, 1907
FROST, GEORGE SHERMAN. Asst. Engr., Public Service Comm. for the First Dist., State of New York, 23 Flatbush Ave., Brooklyn, N. Y. *(Jun., April 2, 1901)*	Jan. 7, 1903
FRUIT, JOHN CLYDE. Asst. to Western Div. Operating Mgr., Am. Bridge Co., 1320 Commercial National Bank Bldg., Chicago, Ill. *(Jun., May 2, 1905)*	Dec. 4, 1907
FRYE, HARLEY EDGAR. U. S. Engr. Office, Zanesville, Ohio	June 1, 1909
FUCIK, EDWARD JAMES. Engr., Great Lakes Dredge & Dock Co., Chicago, Ill	Oct. 2, 1907
FULLER, ANDREW DANIEL. Treas., Andrew D. Fuller Co., Contrs. and Engrs., 3 Hamilton Pl., Boston, Mass. *(Jun., Dec. 6, 1898)*	Jan. 6, 1904
FULLER, CARL HAMILTON. Supt. and Engr., Cook Constr. Co., 518 Good Blk., Des Moines, Iowa. *(Jun., Mar. 5, 1901)*	Feb. 3, 1904
FULLER, WESTON EARLE. Cons. Engr. (Hazen & Whipple), 103 Park Ave., New York City	June 7, 1905
FULWEILER, WALTER HERBERT. With Dept. of Tests, United Gas Impvt. Co. of Philadelphia, Virginia Ave., West Chester, Pa	Nov. 1, 1910
FUQUA, PAUL DAVID. Asst. Engr., Subway Constr., Joint Railroads, 681 Rayburn Boulevard, Memphis, Tenn	Oct. 4, 1910
FURLOW, FELDER. Asst. Engr., Southern Ry., 1240 Maplewood St., Birmingham, Ala	April 6, 1909
FYSHE, THOMAS MAXWELL. (Fyshe, Martin & Co., Ltd.), Room 304, Dominion Bank Bldg., Calgary, Alta., Canada	Jan. 31, 1911

ASSOCIATE MEMBERS G

	Date of Membership
Galbreath, William Otto. Div. Engr., National Rys. of Mexico, Chihuahua Shops, Chihuahua, Mexico	April 6, 1904
Gallager, James Pelton. Asst. Engr., Midland Val. R. R., Muskogee, Okla	Oct. 3, 1911
Gallivan, James Henry. Div. Engr., Cent. New England Ry., Cottage St., Poughkeepsie, N. Y	Jan. 2, 1912
Gandolfo, Joseph Harrington. Civ. Engr. with J. G. White & Co., 43 Exchange Pl., New York City	Oct. 2, 1907
Gannett, Farley. Engr., Water Supply Comm. of Pennsylvania, Harrisburg, Pa	April 4, 1906
Ganser, Sylvan Earle. 107 Pembroke St., Boston, Mass	Jan. 2, 1912
Garbi, Louis, Jr. Care, Am. Asphalt & Rubber Co., 600 Harvester Bldg., Chicago, Ill	May 2, 1911
Gardner, Randall Dunbar. Asst. Engr., Room 60, City Hall, Boston, Mass	May 1, 1907
Gardner, Warren. Asst. Engr., Board of Water Supply; 120 West 58th St., New York City	Oct. 3, 1911
Garfield, Chester Arthur. Asst. Engr., Board of Water Supply of New York City, West Shokan, N. Y	Feb. 6, 1912
Garman, Harry Otto. Associate Prof., Civ. Eng., Purdue Univ.; Cons. Engr., Indiana R. R. Comm., Lafayette, Ind. *(Jun., Feb. 28, 1905)*	Oct. 7, 1908
Garrigues, Henry Haydock. Supervisor No. 2, Allegheny Div., P. R. R., Kittanning, Pa. *(Jun., Oct. 31, 1905)*	June 30, 1910
Gartensteig, Charles. Engr. of Design, Office of Pres., Borough of the Bronx, 177th St. and Third Ave. (Res., 30 West 85th St.), New York City. *(Jun., Oct. 6, 1896)*	May 6, 1903
Garver, Neal Bryant. Instr. in Structural Eng., Univ. of Illinois, Urbana, Ill	May 3, 1910
Gass, Elmer John. 719 Herman W. Hellman Bldg., Los Angeles, Cal	Dec. 6, 1910
Gaston y Rosell, Francisco José. Engr., River and Harbor Impvts., Dept. of Public Works (Res., 56 Seventh St., Vedado), Havana, Cuba	June 6, 1911
Gaumer, Albert Wesley. Chf. Engr., Juragua Iron Co., Firmeza, Santiago de Cuba, Cuba	May 31, 1910
Gay, Howard Spooner. Res. Engr., Care, Vielé, Blackwell & Buck, R. D. 2, Little Falls, N. Y	Dec. 6, 1910
Gay, Leon Lincoln. Orleans, Vt. *(Jun., Dec. 5, 1905)*	Oct. 2, 1907
Gaylord, Laurence Timmerman. Gen. Supt., Southern Dist., Atlantic, Gulf & Pacific Co., Box 756, Mobile, Ala	Nov. 4, 1908
Gearhart, Walter Scott. State Engr., Kansas State Agri. Coll., Manhattan, Kans	June 3, 1908
Geddes, Donald Young. Contr. Agt., The Mt. Vernon Bridge Co., Zanesville, Ohio	Dec. 5, 1911
Gehring, Herbert August. Asst. Engr., New York State Barge Canal Office, Albany, N. Y	May 3, 1910
Gellatly, John Thompson Bisset. Res. Engr., Smartt Syndicate Irrig. Works, Britstown, Cape Colony, South Africa	Jan. 2, 1907
Gentner, Otto Henry, Jr. Chf. Engr., Phila. Fireproofing Co., 1341 Arch St., Philadelphia, Pa	Nov. 4, 1908
Gersbach, Edward Charles. Supt. of Constr., Hogback Canal, Liberty, N. Mex	June 1, 1909
Gibboney, Franklin Lincoln. City Engr., Roanoke, Va	Oct. 31, 1911
Gibbs, Elbert Allan. Engr. of Erection, McClintic-Marshall Constr. Co., Pittsburgh, Pa. *(Jun., Mar. 6, 1906)*	July 1, 1909
Gibson, William Loane. Engr. in Chg., Bolivian Branches, Antofagasta á Bolivia Ry., Oruro, Bolivia	May 6, 1908
Giesey, Jesse K. Asst. Engr., Hering & Gregory, 170 Broadway, New York City	Dec. 5, 1911
Gifford, Lester Robinson. 94 Porter Bldg., Memphis, Tenn. *(Jun., Mar. 3, 1896)*	Dec. 3, 1902
Gilbert, Archibald Marvine. 201 Mode Bldg., Boise, Idaho	May 4, 1909
Gilbert, George Herbert. Engr., Bridges and Bldgs., C., N. O. & T. P. Ry., A. G. S. R. R., Queen & Crescent Route, 133 Ingalls Bldg., Cincinnati, Ohio	June 3, 1908
Gildersleeve, George Snyder. Contr. Engr., Trussed Concrete Steel Co. (Res., 421 Second Ave.), Detroit, Mich. *(Jun., Feb. 5, 1907)*	Aug. 31, 1909
Giles, Arthur Leonard. Glenside, Pa	Oct. 4, 1905
Giles, James Marvin. Superv. Engr., Porto Rico Irrig. Service, Guayama, Porto Rico	Sept. 2, 1908
Gilkey, Thomas Alvin. Cons. Engr., 709 Lawrence Savings & Trust Co. Bldg., New Castle, Pa	Oct. 3, 1900
Gillen, Walter Joseph. Asst. Engr., Bureau of Public Bldgs. and Offices (Res., 824 East 169th St.), New York City. *(Jun., Oct. 31, 1905)*	July 1, 1909
Gillham, Philip Dakin. Dist. Mgr. of Sales, Corrugated Bar Co., 402 Mutual Life Bldg., Buffalo, N. Y. *(Jun., Oct. 30, 1906)*	April 4, 1911

	Date of Membership
Gilman, Charles. 1228 Lenox Ave., Plainfield, N. J. (*Jun., Dec. 6, 1904*)	June 6, 1911
Gilman, Charles Edward. Civ. and Min. Engr. with Duryea, Haehl & Gilman, Cons. Engrs., 1314 Humboldt Bank Bldg., San Francisco, Cal. (*Jun., Oct. 6, 1903*)	Dec. 5, 1906
Goddard, Herbert Willard. Mgr. of Reinforced Concrete Dept., R. H. Howes Constr. Co., 105 West 40th St., New York City. (*Jun., Jan. 3, 1905*)	Jan. 5, 1909
Goldenberg, Maurice. Mgr. of Sales, Trussed Concrete Steel Co., Trussed Concrete Bldg., Detroit, Mich	Feb. 7, 1906
Golding, Thomas Wund. Engr. for Thomas Reilly, Philadelphia, Pa.; Res., 8654 Nineteenth Ave., Brooklyn, N. Y	Jan. 31, 1911
Goldsmith, Clarence. Asst. Engr. in Chg. of High Pressure Fire Service, Public Works Dept., City of Boston, 1 City Sq., Charlestown, Mass	Dec. 6, 1910
Goldsmith, Nathaniel Oliver. Care, The Weir Frog Co., Norwood, Ohio. (*Jun., June 2, 1886*)	June 6, 1900
Goodell, John Stanton. Honolulu, Hawaii	Mar. 7, 1906
Goodman, Harry Minott. Chf. Engr., Lord-Young Eng. Co., P. O. Box 592, Honolulu, Hawaii. (*Jun., June 4, 1907*)	Feb. 28, 1911
Goodman, Joseph. Asst. Engr., Dept. of Water Supply, Gas, and Electricity, Borough of Brooklyn, 157 West 111th St., New York City.	June 6, 1906
Goodman, Leon. 519 Utica Bldg., Des Moines, Iowa	June 30, 1910
Goodman, Louis. Asst. Engr., Dept. of Water Supply, Gas, and Electricity, 13 Park Row, New York City	Oct. 5, 1909
Goodridge, John Wesley. Contr. Engr., Litchfield Constr. Co., 23 Flatbush Ave., Brooklyn, N. Y. (*Jun., Oct. 4, 1898*)	April 5, 1905
Goodsell, Daniel Bertholf. 549 Riverside Drive, New York City	May 6, 1908
Goodwin, Irving Dean. Des Moines Bridge & Iron Works, Curry Bldg., Pittsburgh, Pa. (*Jun., Dec. 3, 1907*)	Jan. 3, 1911
Gordon, John Blake. 3023 Q St., N. W., Washington, D. C. (*Jun., Dec. 1, 1903*)	June 7, 1905
Gorton, Willard Livermore. Acting Chf. Irrig. Engr., Bureau of Public Works, Manila, Philippine Islands	May 3, 1910
Gough, William Joseph. Asst. Engr., Coronado Beach Co., San Diego, Cal	Mar. 4, 1908
Gow, Charles Rice. Civ. Engr. and Contr., 25 Montview St., West Roxbury, Mass	June 1, 1904
Gowdy, Roy Cotsworth. Chf. Engr., Ft. Worth & Denver City Ry. and Wichita Val. Lines, 514 Ft. Worth National Bank Bldg., Fort Worth, Tex	Oct. 31, 1911
Gowen, Sumner. Asst. Engr., Phœnix Bridge Co., Phœnixville, Pa. (*Jun., May 2, 1899*)	June 4, 1902
Grady, John Edward. Engr., Lake Erie Div., Great Lakes Dredge & Dock Co., 1486 E. 116th St., Cleveland, Ohio	Dec. 6, 1905
Graham, Douglas Basil Adair. Asst. Engr., Alvord & Burdick, 1417 Hartford Bldg., Chicago, Ill	Sept. 5, 1911
Graham, Edgar Miller. Cons. Engr., Muskogee, Okla	Oct. 5, 1909
Gram, Lewis Merritt. Structural Engr., 1047 Spitzer Bldg., Toledo, Ohio.	June 1, 1909
Grant, John Robert. 503 Cotton Bldg., Vancouver, B. C., Canada	Jan. 3, 1911
Grant, Joseph Alexander. Care, P. Lyall & Sons Constr. Co., Ltd., Montreal, Que., Canada	May 31, 1910
Grant, Kenneth Crothers. Prin. Asst. Engr., Pittsburgh Flood Comm., 1806 Arrott Bldg., Pittsburgh, Pa	Feb. 2, 1909
Grant, Lloyd Murray. Chf. Engr., Pacific Coast Pipe Co., Ballard Station, Seattle, Wash	Sept. 5, 1911
Grant, Thomas Henry. Red Bank, N. J	May 6, 1891
Grant, Ulysses S, 3d. First Lieut., Corps of Engrs.; Supt., State, War, and Navy Bldg., Washington, D. C	Aug. 31, 1909
Gravell, William Henry. Cons. Engr., 1218 Chestnut St., Philadelphia, Pa	April 4, 1911
Gravelle, Alvin. Asst. Bridge Engr., 311 City Hall, Cleveland, Ohio	Nov. 6, 1901
Graves, Willard Franklin. 4563 Woodlawn Ave., 3d Aprt., Chicago, Ill. (*Jun., Oct. 31, 1899*)	Jan. 4, 1905
Gray, Edward, Jr. Asst. Engr., C. & O. Ry., The Woodford, Covington, Ky	Jan. 2, 1895
Gray, Harry Woy. Asst. Prof. in Experimental Civ. Eng., Iowa State Coll., Ames, Iowa	Nov. 1, 1910
Gray, Henry Lilburn. Engr., R. R. Comm. of Wash., Olympia, Wash	July 1, 1909
Gray, John Lathrop. Asst. Gen. Supt., Tide Water Oil Co., East 22d St., Bayonne, N. J	Dec. 6, 1905
Gray, Walter Thomas. Engr. of Constr., Sewer Dept. (Res., 6908 Virginia Ave.), St. Louis, Mo	Oct. 7, 1908
Gray, William. Asst. Engr., Bureau of Sewers, Borough of Bronx, New York City. (*Jun., May 2, 1888*)	Mar. 1, 1893
Gray, William Bacon. Gen. Supt., S. Pearson & Son, Inc., 507 Fifth Ave., New York City	Aug. 31, 1909

	Date of Membership
Gray, William David. 1237 South Garvin Pl., Louisville, Ky	Oct. 7, 1908
Green, Andrew H. Canefield, Dominica	Oct. 2, 1901
Green, Charles Newton. Asst. Engr., Public Service Comm., First Dist., 154 Nassau St., New York City	June 3, 1903
Green, Fred May. 43 Norwood Ave., Buffalo, N. Y	April 6, 1904
Green, James Arleigh. Pres., Jas. A. Green & Co., Inc., 111 West Monroe St., Chicago, Ill	Jan. 8, 1908
Green, James Cowan. 858 Myrtle Ave., Albany, N. Y	April 6, 1909
Green, Paul Evans. Cons. Civ. and San. Engr., 17 North La Salle St., Chicago, Ill	July 10, 1907
Green, Theodore. 5102 Stewart Pl., Madisonville, Ohio	Mar. 1, 1910
Greenalch, Wallace. Commr. of Public Works, Albany, N. Y. (*Jun., April 3, 1894*)	June 7, 1899
Greene, Albert Emerson. Prof. of Civ. Eng., Univ. of Michigan, 415 E. William St., Ann Arbor, Mich	May 4, 1904
Greene, Carleton. Div. Engr., Barge Canal Terminals, State Engr.'s Dept., 17 Battery Pl., New York City	Mar. 3, 1897
Greene, Frederick Stuart. Vice-Pres. and Gen. Mgr., The Waterproofing Co., 150 East 36th St., New York City	June 7, 1899
Greene, Howard Arnold. Div. Erecting Mgr., Am. Bridge Co. of N. Y., 1525 Frick Bldg., Pittsburgh, Pa	June 5, 1895
Greene, Lloyd Woolsey. Asst. Engr., N. Y. C. & H. R. R. R. (Res., 132 East 8th St.), Oswego, N. Y. (*Jun., Sept. 1, 1908*)	Oct. 31, 1911
Greenlaw, Ralph Weller. Asst. Engr., Board of Water Supply of New York City, 250 West 54th St., New York City. (*Jun., May 3, 1904*)	June 6, 1911
Greenman, Russell Soule. Res. Engr., Testing Laboratory, State Engr.'s Dept., State Hall, Albany, N. Y	Aug. 31, 1909
Greensfelder, Albert Preston. Secy., Fruin-Colnon Contr. Co., 506 Merchants Laclede Bldg., St. Louis, Mo. (*Jun., May 3, 1904*)	May 2, 1906
Greenwood, Albert Henry. (Greenwood & Noerr), 847 Main St. (Res., 39 Copen St.), Hartford, Conn	Feb. 1, 1905
Gregg, Tresham Dames. Bridge Insp., C., R. I. & P. Ry., 5489 Lexington Ave., Chicago, Ill	May 2, 1911
Gregory, Alfred Cookman. Engr. of Sewers. (Res., 555 Rutherford Ave.), Trenton, N. J	June 5, 1907
Gregory, Charles Emerson. Mt. Kisco, N. Y. (*Jun., Oct. 6, 1896*)	Mar. 6, 1901
Greifenhagen, Edwin Oscar. With Arthur Young & Co., 1315 Monadnock Bldg., Chicago, Ill	Oct. 31, 1911
Griffin, Arthur James. Engr. of Constr., Bureau of Sewers, 215 Montague St., Brooklyn, N. Y	Dec. 7, 1904
Griffin, John Alexander. Norcross, Ga	Jan. 3, 1911
Griffin, Thomas Stephen. With J. A. Fitzpatrick, Inc., 1123 Broadway, New York City	May 2, 1911
Griffith, John Howell. Engr.-Physicist, Bureau of Standards, Dept. of Comm. and Labor, Pittsburgh, Pa	April 3, 1907
Griffith, Lawrence. Cons. Engr., Yonkers, N. Y	May 2, 1900
Griffith, William Francis Roelofson. 40 Maple Ave., Morristown, N. J	May 2, 1911
Grimm, Henry England. P. O. Box 640, Chicago, Ill. (*Jun., Oct. 2, 1900*)	Nov. 4, 1908
Griswold, Harry Todd. Old Lyme, Conn. (*Jun., Oct. 6, 1903*)	Dec. 4, 1907
Griswold, Lee Swaney. U. S. Asst. Engr., U. S. Engr. Office, 414 Custom House, San Francisco, Cal	Dec. 6, 1910
Griswold, Ray Elliott. Pres., Elk Creek Lumber Co., Cottage Grove, Ore	Oct. 1, 1902
Groat, Benjamin Feland. Hydr. Engr., Massena, N. Y	May 3, 1910
Gronwall, Thomas Hagen. Address unknown. (*Jun., Jan. 3, 1907*)	April 6, 1909
Gross, Charles Frederick. Engr. for Wm. Steele & Sons Co., 1600 Arch St., Philadelphia, Pa	Sept. 2, 1908
Gross, Daniel Wingerd. Engr. of Constr., A. C. L. R. R., Wilmington, N. C	May 1, 1901
Grover, Nathan Clifford. Chf. Engr., Land Classification Board, U. S. Geological Survey, Washington, D. C	Mar. 2, 1904
Grover, Oscar Llewellyn. Bridge Engr., C. & O. Ry., 8th and Main Sts., Richmond, Va	Mar. 2, 1909
Gubelman, Frederick Joseph. Pres., The Regina Co., Eastern Constr. Co.; Secy.-Treas., Gubelman Pub. Co., 47 West 34th St., New York City	Oct. 2, 1895
Gude, Albert Valdemar, Jr. 712 Grant Bldg., Atlanta, Ga	June 5, 1907
Gudewill, Charles Edward. Vice-Pres., Montreal Pipe Foundry Co., P. O. Box 2304, Montreal, Que., Canada	Sept. 1, 1897
Gudmundsson, Gisli. Empire Bldg., Pittsburgh, Pa	Jan. 3, 1900
Gueringer, Louis Amedee. Locating Engr., Frisco Lines, Victoria, Tex.	May 7, 1902
Guise, Philip. Asst. Engr., Dept. of Docks and Ferries, Gowanus Section, Office, Foot of 32d St., Brooklyn, N. Y	Nov. 6, 1907

	Date of Membership
Gundersen, August. Care, Hoyer Ellefsen, Toldbodgaden 30, Christiania, Norway	Oct. 2, 1907
Gustafson, Gustaf Edward. Bldg. Constr. Engr., Board of Education, 1229 Addison Ave., Chicago, Ill	July 10, 1907
Gustin, R Prosper. 285 Rich Ave., Mt. Vernon, N. Y	May 1, 1907
Guthrie, Keith Osmond. Eng. Contr., Waterford, N. Y	May 3, 1905

Haas, Philip Lippman. Asst. Engr., New York State Highway Comm. (Res., 49 South Cherry St.), Poughkeepsie, N. Y	May 6, 1908
Hadwen, Theodore Lovel Donner. Engr. of Masonry Constr., Eng. Dept., C., M. & St. P. Ry., 1347 Railway Exchange, Chicago, Ill	Oct. 7, 1908
Haehl, Harry Lewis. With Duryea, Haehl & Gilman, 1314 Humboldt Bank Bldg., San Francisco, Cal. (*Jun., Oct. 6, 1903*)	July 9, 1906
Hagar, Edward McKim. Pres., Universal Portland Cement Co., 1434 Commercial Bank Bldg., Chicago, Ill	Feb. 6, 1901
Hager, Albert Bertram. Secy., Fidelity Eng. & Inspecting Co., 30 Church St., New York City	Nov. 1, 1905
Haggart, Cecil Neil. 79 N. Allen St., Albany, N. Y	May 6, 1908
Hague, William. 22 William St., New York City	Oct. 4, 1910
Hain, James C. 509 Delta Bldg., Los Angeles, Cal	May 1, 1901
Halcombe, Norman Marshall. Box 250, Stanford University, Cal. (*Jun., Sept. 3, 1907*)	May 2, 1911
Haldeman, Walter Stanley. Chf. Engr., H. L. Stevens & Co., 510 Hall Bldg., Kansas City, Mo	Oct. 5, 1909
Hale, Richard King. Cons. Engr. (Richardson & Hale), 85 Water St., Boston, Mass. (*Jun., April 4, 1905*)	Feb. 1, 1910
Hall, Charles Romney. U. S. Asst. Engr., 405 Custom House, San Francisco, Cal	Jan. 7, 1903
Hall, Hubert Harry. In Chg., Eng. Dept., Standard Oil Co. (Div. B), 461 Market St., San Francisco, Cal. (*Jun., April 30, 1907*)	May 3, 1910
Hall, Louis Wells. Engr., U. S. Reclamation Service, Portland, Ore	Oct. 1, 1902
Hall, Martin Welch. Asst. Engr., Bureau of Sewers, Borough of the Bronx, New York City. (*Jun., Oct. 1, 1901*)	Nov. 7, 1906
Hall, Robert Elliot. Pres., Aldrich & Hall, Inc., Auburn, N. Y. (*Jun., Sept. 6, 1904*)	June 30, 1910
Hall, Warren Esterly. Care, Hall Bros., 303 Peters Bldg., Atlanta, Ga. (*Jun., Nov. 5, 1907*)	June 30, 1910
Hall, William Henry. (Hall & Bacon), 272 Main St., New Britain, Conn.	Oct. 4, 1910
Halsey, Edmund Ryond. 164 Market St., Newark, N. J	Feb. 7, 1906
Hamill, Alexander Sylvester. 426 Montgomery St., Jersey City, N. J. (*Jun., Dec. 28, 1900*)	April 6, 1909
Hamill, William Samuel. Gen. Mgr., William S. Hamill Co., 18 State St., Troy, N. Y	Mar. 1, 1910
Hamilton, Farrar Petrie. 662 North State St., Jackson, Miss	June 3, 1908
Hamlin, Ralph. Chf. Engr., Pike & Cook, 416 South 5th St., Minneapolis, Minn. (*Jun., Jan. 5, 1904*)	Oct. 5, 1909
Hammel, Victor Frank. Asst. Engr., In Chg., Drafting Dept., Elec. Bond & Share Co. and Associate Cos., 71 Broadway, New York City	Oct. 31, 1911
Hammond, John Miller. Asst. Div. Engr., Kansas City Terminal Ry., 302 East 43d St., Kansas City, Mo	April 4, 1911
Hammond, Lester Clark. Oyster Bay, N. Y	Oct. 31, 1911
Hanavan, William Lawrence. Asst. Engr., Board of Water Supply of New York City, R. F. D. No. 4, Newburgh, N. Y. (*Jun., Dec. 6, 1904*)	Dec. 6, 1910
Hancock, Henry Sydney, Jr. Cons. Engr., 315 Pacific Bldg., Vancouver, B. C., Canada. (*Jun., Oct. 6, 1903*)	April 5, 1910
Hancock, Lewis Wernette. Pres., The L. W. Hancock Co., Engrs. and Contrs., 1412 Lincoln Bank Bldg., Louisville, Ky	Jan. 2, 1907
Haney, Albert Paul. Dist Engr., Corrugated Bar Co., 801 Grant Bldg., Atlanta, Ga. (*Jun., Nov. 8, 1909*)	Feb. 28, 1911
Haney, Lewis Tustler. Cape Charles, Va. (*Jun., Oct. 7, 1902*)	Mar. 1, 1905
Hanley, William Scott. Div. Engr., N. O., G. N. R. R., Bogalusa, La.	Nov. 1, 1910
Hanna, Walter Scott. Cons. Engr. with J. B. Hogg, Lykens, Pa. (*Jun., Oct. 6, 1903*)	June 5, 1907
Hansell, William Albert. Civ. Engr. and Supt. of Constr., 630 Highland Ave., Atlanta, Ga	Oct. 5, 1909
Hansen, Paul. Engr., Illinois State Water Survey, Urbana, Ill. (*Jun., Jan. 3, 1905*)	April 1, 1908
Harbeck, Henry Russell. Engr. and Supt. of Constr., Leonard Constr. Co., 1937 McCormick Bldg., Chicago, Ill	June 3, 1908
Hardesty, James Robert. Contr. Engr., Virginia Bridge & Iron Co., Roanoke, Va	Feb. 2, 1909
Hardin, Abraham Tracy. Asst. Gen. Mgr., N. Y. C. & H. R. R. R., Grand Central Terminal, New York City	Mar. 2, 1904

	Date of Membership
Harding, Robert John. Supt. of Public Works, Poughkeepsie, N. Y.	Nov. 4, 1908
Hardison, Allen Crosby. Civ. and Min. Engr., Santa Paula, Cal.	Feb. 6, 1901
Hardman, Roy Cordis. Civ. Engr. and Supt. of Constr., War Dept., Fort Huachuca, Ariz.	Oct. 7, 1908
Hardt, Charles William. Asst. Engr., State Highway Dept., Harrisburg, Pa.	July 1, 1909
Harger, Wilson Gardner. 16 Hinsdale St., Rochester, N. Y.	Sept. 5, 1911
Harley, George Foster. Res. Engr., Stone & Webster Eng. Corporation, Box 453, Columbus, Ga.	Jan. 3, 1911
Harlow, James Hayward, Jr. Pres., The James H. Harlow Co., 3 East Lexington St., Baltimore, Md.	Mar. 5, 1902
Harper, Frederick Clayton. Western Mgr., Concrete Steel Co., 1106 Monadnock Blk., Chicago, Ill. *(Jun., April 30, 1907)*	Jan. 2, 1912
Harper, Isaac Onward. Secy. and Treas., Lauer & Harper Co., Westport, Md.	May 7, 1902
Harper, Sinclair Ollason. Asst. Engr., U. S. Reclamation Service, Grand Junction, Colo. *(Jun., Mar. 31, 1908)*	Jan. 3, 1911
Harps, Harry Macy. Fallbridge, Wash. *(Jun., Mar. 3, 1903)*	Oct. 2, 1907
Harrington, Allan Collins. Cons. Engr., 413 North Delaware St., Indianapolis, Ind.	Oct. 2, 1907
Harrington, Francis Burchard. Trainmaster, N. Y. C. & H. R. R. R., Union Station, Albany, N. Y. *(Jun., Sept. 11, 1900)*	Feb. 5, 1908
Harrington, Harry Garfield. 39 Pacific St., Newark, N. J. *(Jun., Jan. 7, 1902)*	Feb. 7, 1906
Harris, Archie Lee. 418 Fleming Bldg., Phœnix, Ariz.	May 31, 1910
Harris, Borden Baker. P. O. Box 833, Chico, Cal.	April 3, 1907
Harris, George Henry. Div. Engr., M. C. R. R., St. Thomas, Ont., Canada.	May 3, 1910
Harris, Guy Walter. Chf. Engr. of Constr., The Pecos & Northern Texas Ry., Amarillo, Tex.	June 5, 1907
Harris, Henry Alexander. 176 Nassau St., Princeton, N. J. *(Jun., Oct. 31, 1899)*	June 7, 1905
Harris, Jay Butler. Reinforced Concrete Engr., 521 Citizens National Bank Bldg., Los Angeles, Cal.	Oct. 2, 1907
Harrison, Edward Lee. Designing Engr., G. M. Shaw & Co., 1503 Tenn. Trust Bldg., Memphis, Tenn.	Dec. 5, 1911
Harrison, Russell Edwin. Res. Engr. in Chg. of Constr., Filtration Plant, Quimby St., Grand Rapids, Mich. *(Jun., Oct. 30, 1906)*	June 6, 1911
Harshbarger, Elmer Dwight. Engr., Pitt Constr. Co., 821 Fulton Bldg., Pittsburgh, Pa. *(Jun., Nov. 5, 1901)*	Jan. 3, 1906
Hart, Reuben Charles. City and County Engr., Howes Blk., Clinton, Iowa	Sept. 2, 1908
Harting, Otto Frederick. Prin. Asst. Engr., Terminal R. R. Assoc. of St. Louis (Res., 3817 Russell Ave.), St. Louis, Mo.	April 5, 1910
Hartman, Alfred Hanson. Div. Engr., Storm Water and Low Level Divs., Sewerage Comm., City of Baltimore, 807 American Bldg., Baltimore, Md. *(Jun., Dec. 6, 1904)*	Dec. 5, 1906
Hartman, August Frederick. Engr. with George F. Hardy, 309 Broadway, New York City	Dec. 4, 1907
Hartung, Paul August. Care, Chf. Engr., M. O. & G. Ry., Muskogee, Okla.	Sept. 6, 1910
Harvey, Clarke Kennerley. Asst. Engr. to Harry J. Lewis, 336 Fourth Ave., Pittsburgh, Pa.	May 3, 1910
Hasbrouck, Oscar. Engr. for Holler & Shepard, 3 Main St., Hudson Falls, N. Y. *(Jun., Jan. 3, 1907)*	Nov. 8, 1909
Haselwood, Fred Willis. Civ. and Hydr. Engr., 1624 Bonita Ave., Berkeley, Cal. *(Jun., Jan. 3, 1907)*	Sept. 6, 1910
Haskell, Frank Hampton. Div. Engr., C. & O. Ry., Covington, Ky.	Jan. 8, 1908
Hastings, Edgar Morton. Res. Engr., R., F. & P. R. R., Richmond, Va.	June 30, 1910
Hatt, William Kendrick. Prof. of Civ. Eng., Purdue Univ.; Civ. Engr., Forest Service, U. S. Dept. of Agri., Lafayette, Ind.	June 4, 1902
Hattan, William Cary. Box 512, Lexington, Va.	Nov. 6, 1907
Hatton, Herbert Watson. Cons. Engr., Folcroft, Pa. *(Jun., April 4, 1905)*	June 1, 1909
Hauck, William. Room 2003, Park Row Bldg., New York City	June 5, 1901
Havens, Ralph DeWitt. 144 Bedford St., Stamford, Conn.	Aug. 31, 1909
Havens, Verne Le Roy. Care, Brazil Ry., São Paulo, Brazil. *(Jun., Oct. 3, 1905)*	April 1, 1908
Hawkesworth, John. 100 West 80th St., New York City. *(Jun., Sept. 6, 1904)*	Nov. 4, 1908
Hawley, Charles Ray. Railroad Contr. (T. Towles & Co.), Wise, Va. *(Jun., Feb. 5, 1907)*	April 5, 1910
Hawley, George Prince. Care, Shawinigan Water & Power Co., Shawinigan Falls, Que., Canada	Feb. 6, 1901
Hawn, Russell John. Supt., Virginia Portland Cement Co., Fordwick, Va.	Nov. 30, 1909
Hayden, Edwin Clapp. 16 City Sq., Room 4, Charlestown, Mass. *(Jun., Oct. 1, 1901)*	June 7, 1905

	Date of Membership
Hayes, Andrew Jenkins. Care, U. S. Reclamation Service, Fort Shaw, Mont	Sept. 6, 1910
Hayes, Charles Edward. Asst. Engr., U. S. Reclamation Service, Helena, Mont. (*Jun., Mar. 6, 1906*)	May 31, 1910
Hayes, Morgan Dodge. Care, The Midvale Steel Co., Brunswick Bldg., New York City	April 1, 1903
Hayes, Ralph Daniel. Stillwater, N. Y. (*Jun., June 4, 1907*)	Aug. 31, 1909
Hayes, Roy Bagley. Supt. of Constr., Post Office Bldg., Lexington, Ky	Oct. 31, 1911
Haynes, Claude Sanford. Asst. Engr., Bureau of Sewers, 261 Montague St., Room 916, Brooklyn, N. Y	Jan. 4, 1910
Haynes, George Albert. Engr. and Gen. Mgr., Stone City Steel Constr. Co., Bedford, Ind	Sept. 2, 1908
Hays, David Walker. Reno, Nev	May 31, 1910
Hays, Don. 701 E. A St., North Yakima, Wash	May 6, 1903
Hays, Donald Symington. Care, Mt. Hood Ry. & Power Co., Portland, Ore	Oct. 4, 1910
Haywood, Charles Ellsworth. Asst. Engr., Gibbs & Hill, Cons. Engrs., Pennsylvania Station, New York City. (*Jun., Nov. 8, 1909*)	Feb. 6, 1912
Hazard, Erskine. 725 Hill Ave., Wilkinsburg, Pa	Oct. 2, 1895
Hazard, William Abbott. Mgr., Lackawanna Bridge Co., P. O. Box 97, Buffalo, N. Y	Nov. 8, 1909
Hazelton, William Sylvester. Mgr., Chicago Office, Corrugated Bar Co., 1825 Commercial National Bank Bldg., Chicago, Ill	May 4, 1909
Hazlett, Robert. City Bank Bldg., Wheeling, W. Va	Mar. 4, 1896
Heald, Edward Creswell. Chf. Structural Engr., Office of Superv. Archt., Treasury Dept., Washington, D. C. (*Jun., Oct. 7, 1902*)	May 2, 1906
Healey, Charles Frank. Prin. Asst. Engr., Green River Gravity System, City of Tacoma, 607 South Sheridan Ave., Tacoma, Wash	June 30, 1910
Healy, John Paul. Prin. Asst. Insp. of Bldgs., Dist. of Columbia, Washington, D. C	Dec. 6, 1910
Hebard, Roy William. Panama, Panama	Feb. 6, 1907
Heck, Nicholas Hunter. Asst., U. S. Coast and Geodetic Survey, Washington, D. C	July 1, 1909
Heer, William, Jr. U. S. Junior Engr., Pennington, Ala. (*Jun., Nov. 5, 1907*)	April 6, 1909
Heiges, Thomas Tyrrell. 47 E. Market St., York, Pa	Feb. 5, 1908
Heindle, William Albert. Mgr. of Railways, Wilmington & Philadelphia Traction Co. and Southern Pennsylvania Traction Co., Wilmington, Del	Nov. 6, 1901
Heller, John Walter. Eng. Contr., Firemen's Bldg., Newark, N. J	June 6, 1906
Helvern, Dan Edwin. Div. Engr., A., T. & S. F. Ry., 33 Carlile Pl., Pueblo, Colo	Jan. 31, 1911
Henderson, Adelbert Andrew. County Engr.'s Office, Room 308, Court House, Pittsburgh, Pa	April 4, 1906
Henderson, Samuel Whilden. Gen. Mgr., Marysville Light, Power & Water Co.; Vice-Pres. and Gen. Mgr., Excelsior Water, Gas & Elec. Co., Excelsior Springs, Mo	Sept. 6, 1905
Hendrick, Edward Pierson. Civ. Engr. and Supt. of Constr., Quartermaster's Dept., U. S. A., 263 Summer St., Room 204, Boston, Mass	April 4, 1911
Hendricks, Kearney Everett. Instr. in Civ. Eng., Lehigh Univ., South Bethlehem, Pa	Oct. 4, 1910
Henley, Robert Dwiggins Monteith. Care, Chf. Engr., Kansas City South. Ry., Kansas City, Mo. (*Jun., Sept. 3, 1901*)	Jan. 31, 1911
Henry, Francis Maxwell. Lumber Exchange, Minneapolis, Minn	Mar. 4, 1896
Hermanns, Frank Edward. Prof. of Structural Eng., Stevens Inst. of Technology; (Hermanns, Madden & Co.), 103 Park Ave., New York City	Jan. 3, 1906
Herring, Jerome Campbell. Insp. of Maintenance, City Hall, Kansas City, Mo	April 5, 1905
Herron, George Merrick. 854 Middlefield Rd., Palo Alto, Cal. (*Jun., April 2, 1907; Assoc., Feb. 2, 1909*)	Sept. 5, 1911
Hershey, John Logan. Res. Engr., San Miguel Irrig. & Land Co., Norwood, Colo	Jan. 31, 1911
Heslop, Derwent Gordon. Care, Chf. Engr., West Australian Govt. Rys., Perth, Western Australia	May 2, 1911
Hewat, Henry John. 227 Hamilton Ave., Paterson, N. J	April 3, 1907
Hewerdine, Thomas Sloan. Box 161, Fisher, Ill	June 30, 1911
Hewitt, George. Care, Lee & Hewitt, 1123 Broadway, New York City	Oct. 3, 1906
Hidinger, Leroy Lemayne. 612 Goodwyn Inst. Bldg., Memphis, Tenn	Oct. 4, 1910
Higgins, Herman Keene. Cons. Engr., 53 State St., Boston, Mass	Nov. 7, 1906
Higgins, James Wallace. Civ. and Landscape Engr., 347 Fifth Ave., New York City (Res., Roselle Park, N. J.)	April 3, 1907
Higginson, Jonathan Yates. Asst. Engr., N. Y., N. H. & H. R. R., Harlem River Station, New York City (Res., 88 Centre Ave., New Rochelle, N. Y.). (*Jun., Oct. 1, 1901*)	Nov. 8, 1909

	Date of Membership
Highley, Lee. Chf. Engr., Pac. & Idaho North. Ry. Co., New Meadows, Idaho. (*Jun., Dec. 7, 1897*)	Dec. 4, 1901
Hildreth, John Lewis, Jr. Asst. Engr. in Chg., Section 4, Moodna Siphon, Board of Water Supply, Vail Gate, N. Y.	Dec. 6, 1905
Hill, Edwin Allston. Asst. Examiner, Patent Office, 1221 K St., N. W., Washington, D. C.	May 3, 1893
Hill, George Samuel. 601 Hearst Bldg., San Francisco, Cal. (*Jun., Jan. 3, 1907*)	June 1, 1909
Hill, John J. Engr. for James Stewart & Co., New York State Barge Canal Contracts Nos. 12 and 39, 73 Downer St., Baldwinsville, N. Y.	April 5, 1910
Hill, Theodore William. Contr. Engr., Bellefontaine, Ohio	Mar. 7, 1900
Hill, Walter Arthur. Chf. Engr. and Supt., Vera Cruz & Pac. R. R., Calle Real de Churubusco No. 13, Churubusco, D. F., Mexico	Sept. 2, 1896
Hill, Walter Nickerson. Asst. Engr., U. S. Reclamation Service, St. Ignatius, Mont.	Jan. 2, 1912
Hiller, John Augustus. Supt., Distrib., Cincinnati Water-Works, City Hall (Res., 2455 Madison Rd.), Cincinnati, Ohio	Sept. 7, 1904
Hillman, George Waldo. Asst. Engr., Tex. & Pac. Ry., Boyce, La.	April 1, 1908
Hilton, Harry LeGrand. U. S. Navy Yard, P. O. Box 472, Portsmouth, N. H.	June 1, 1909
Hilton, Joseph Churchill. Secy., Mason, Hilton & Co., Contrs., Shelburne Falls, Mass.	Jan. 2, 1907
Hilts, Harold Ezra. 129 Coligni Ave., New Rochelle, N. Y.	May 31, 1910
Hirst, Arthur. Engr., Trenton Plant, Am. Bridge Co., Trenton, N. J.	Dec. 3, 1902
Hoad, William Christian. Prof. of Civ. Eng., Univ. of Kansas; Engr., State Board of Health, Lawrence, Kans.	Dec. 5, 1906
Hoard, Clarence. Chf. Engr., Victoria & Barkley Sound Ry., P. O. Box 216, Victoria, B. C., Canada	Feb. 28, 1911
Hodgdon, Benjamin Alexander. Asst. Engr., Public Service Comm. for First Dist., State of New York, 154 Nassau St., New York City	Mar. 2, 1909
Hodgdon, John Brewster. City Engr.; Asst. Engr., M., K. & T. Ry., 2101 Wall St., Joplin, Mo.	April 3, 1907
Hoffman, William Otto. Care, H. C. Stowe Constr. Co., 221 Greenpoint Ave., Brooklyn, N. Y.	Jan. 8, 1908
Hogue, Charles Jay. Constr. Engr., Manila R. R., Manila, Philippine Islands	Dec. 7, 1898
Holbrook, Percy. Vice-Pres., The Rail Joint Co., 185 Madison Ave., New York City	Mar. 2, 1898
Holbrook, Winfield. Chf. Engr., Beaver Land & Irrig. Co., Penrose, Colo. (*Jun., Mar. 3, 1908*)	Oct. 4, 1910
Holden, Charles Alexander. Asst. San. Engr., Met. Sewerage Comm. of New York, 17 Battery Pl., New York City	Feb. 28, 1911
Holden, Charles Arthur. Prof. of Civ. Eng., Thayer School of Civ. Eng., Dartmouth Coll., Hanover, N. H. (*Assoc., Nov. 1, 1905*)	Mar. 1, 1910
Holdredge, Neil Cummings. 154 East 175th St., New York City	Oct. 31, 1911
Holdrege, Henry Atkinson. Gen. Mgr., Omaha Elec. Light & Power Co., Omaha, Nebr.	Dec. 7, 1904
Holley, Carl Hiram. Gen. Mgr., Tulare County Power Co., Lindsay, Cal.	June 5, 1907
Holley, Harry Hall. Visalia, Cal.	Oct. 5, 1909
Holliday, Alexander Rieman. Secy., The National Concrete Co., 805 Traction Terminal Bldg., Indianapolis, Ind. (*Jun., Oct. 7, 1902*)	Feb. 1, 1905
Holmes, Frank. Asst. Engr., Thompson-Starrett Co., 51 Wall St., New York City	Dec. 1, 1908
Holt, Lester Morton. Irrig. Engr., U. S. Indian Service, 3551 Thirteenth St., N. W., Washington, D. C.	Oct. 3, 1906
Holtsmark, Erling. Public Service Comm., 154 Nassau St., New York City	April 1, 1908
Homan, William MacLean. ,Cons. Engr. and Govt. Land Surv., Bethlehem, Orange River Colony, South Africa	June 7, 1899
Honeyman, Bruce Ritchie. Secy. and Chf. Engr., Northwest Bridge Works, 768 Quimby St., Portland, Ore.	Sept. 5, 1911
Honness, George Gill. Div. Engr., Board of Water Supply, Pleasantville, Westchester Co., N. Y. (*Jun., Feb. 2, 1897*)	Sept. 4, 1901
Hood, Hugh Kendall. Res. Engr. for Hardaway Contr. Co., Smiths Station, Ala.	Feb. 1, 1910
Hood, James Henry. Supt. of Constr., Stone & Webster Eng. Corporation, 147 Milk St., Boston, Mass.	April 5, 1910
Hood, Joseph Nelson. Engr., Pittsburgh Contr. Co., 236 Grand St., Newburgh, N. Y.	April 3, 1907
Hopkins, Albert Lloyd. Mgr., Newport News Shipbuilding & Dry Dock Co., Newport News, Va. (*Jun., April 3, 1894*)	April 3, 1901
Hopper, Jean Georges LeFebvre. 404 Balboa Bldg., San Francisco, Cal.	Sept. 5, 1911
Horne, Harold Wellington. Div. Engr., Board of Water Commrs. of Hartford, New Hartford, Conn.	Oct. 2, 1907

	Date of Membership
Horner, Wesley Winans. Prin. Asst. Engr., Sewer Dept., St. Louis, Mo. (*Jun., Sept. 1, 1908*)	April 4, 1911
Horstman, Joseph Prosper. Engr. and Gen. Supt., Parkersburg, Marietta & Inter-Urban Ry., Parkersburg, W. Va	Dec. 7, 1904
Hortenstine, Henry Roberts. Contr. Mgr., Penn Bridge Co., Beaver Falls, Pa	April 3, 1907
Hortenstine, James Wilson. Roadmaster, Guantanamo & West. R. R., Guantanamo, Cuba	Oct. 3, 1911
Horton, Albert Howard. Dist. Engr., U. S. Geological Survey, Federal Bldg., Newport, Ky. (*Jun., June 3, 1902*)	Mar. 6, 1907
Horton, Dwight Fred. Chf. Engr., Houston Land Corporation, Houston, Tex. (*Jun., June 6, 1905*)	Feb. 5, 1908
Hosmer, Guy Frederic. With O. Perry Sarle, 146 Westminster St., Providence, R. I	Nov. 6, 1907
Hosmer, Ralph Herbert. Telegraph Bldg., Harrisburg, Pa	Dec. 6, 1910
Hough, Frederick Milton. Contr. Engr., San Juan, Tex	Nov. 6, 1907
Houser, Shaler Charles. Engr. for Erwin Marx, Guantanamo, Cuba	Sept. 5, 1911
Houston, John Jay Lafayette. 19 Union Hall St., Jamaica, N. Y	Jan. 2, 1912
Hovey, Ray Palmer. With Utah Copper Co., Salt Lake City, Utah. (*Jun., Jan. 2, 1906*)	Nov. 8, 1909
Howalt, Wilhelm Jens Christian. 590 West 174th St., New York City	June 5, 1907
Howard, Conway Robinson. Chf. Engr., New Orleans, Great North. R. R. and Great Southern Lumber Co., Box 56, Bogalusa, La	Dec. 5, 1906
Howard, Ernest Emmanuel. Associate Engr., Waddell & Harrington, 1012 Baltimore Ave., Kansas City, Mo. (*Jun., Dec. 3, 1901*)	Sept. 6, 1905
Howard, Lewis Thomas. Asst. Engr., New York Barge Canal, Schuylerville, N. Y	June 3, 1908
Howard, Oliver Zell. Care, The Griscom Spencer Co., 90 West St., New York City	Feb. 28, 1911
Howe, Charles Edward. Asst. Supt., Hastings Pavement Co., Hastings-on-Hudson, N. Y. (*Jun., Mar. 6, 1900*)	May 3, 1905
Howe, Clarence Durand. Project Engr., U. S. Reclamation Service, Huntley, Mont	Feb. 1, 1910
Howe, Harry Northrop. Engr. (Gardner & Howe), 76 Porter Bldg., Memphis, Tenn. (*Jun., Dec. 6, 1904*)	April 5, 1910
Howe, Herbert Frank. Care, Guayaquil & Quito Ry., Guayaquil, Ecuador	Oct. 2, 1907
Howe, Walter Clark. Asst. City Engr., Oakland, Cal	May 31, 1910
Howell, Cleves Harrison. Phœnix, Ariz	Feb. 28, 1911
Howell, Frank Scott. Civ. Engr. in Chg., U. S. Immigrant Station, Ellis Island, New York Harbor, N. Y. (Res., New York Athletic Club, Central Park South, New York City)	April 4, 1906
Howell, Robert Parsons. Town Surv. and Civ. Engr., 41 Brainard St., Phillipsburg, N. J	Oct. 4, 1905
Howie, Howard Benson Wilberforce. Chf. Engr., West Constr. Co., Chattanooga, Tenn. (*Jun., Mar. 6, 1906*)	Dec. 6, 1910
Hoyt, Henry Perez. Fort Fairfield, Me. (*Jun., Oct. 6, 1903*)	Dec. 4, 1907
Hoyt, John T Noye. Care, Albert Kahn, 58 Lafayette Boulevard, Detroit, Mich. (*Jun., Feb. 28, 1893*)	Mar. 2, 1898
Hubbard, Winfred Dean. Asst. Engr., Board of Water Supply, City of New York, West Shokan, N. Y	Nov. 5, 1902
Hubbell, George Scott. 314 West 94th St., New York City	June 1, 1904
Huber, Walter Leroy. Dist. Engr., Dist. 5, U. S. Forest Service, 1204 First National Bank Bldg., San Francisco, Cal. (*Jun., April 3, 1906*)	Mar. 1, 1910
Hudson, Darwin Shaw. Field Engr., Constr. Dept., The Astoria Light, Heat & Power Co. (Res., 157 Franklin St.), Astoria, N. Y	April 5, 1910
Hudson, Harold Walton. 2 South Morris Ave., Atlantic City, N. J	May 3, 1905
Huestis, Charles Calvin. Secy. and Gen. Mgr., Essex Constr. Co., 279 Highland Ave., Buffalo, N. Y	Mar. 6, 1901
Huff, Clyde Leslie. P. O. Box 671, Boise, Idaho	July 1, 1909
Hufschmidt, William Paul. Vallery, Colo	Oct. 4, 1910
Hughes, Francis Dey. Contr. Mgr. and Engr., Illinois Steel Bridge Co., 521 Reliance Bldg., Kansas City, Mo	Sept. 3, 1902
Hulburd, Lucius Sanford. Res. Engr., New York State Barge Canal, Seneca Falls, N. Y	Oct. 31, 1911
Hulsart, Charles Raymond. Asst. Engr., Board of Water Supply (Res., 2348 Seventh Ave.), New York City	Jan. 31, 1911
Hulse, Shirley Clark. Mexican Northern Power Co., Ltd., Santa Rosalia, Chihuahua, Mexico. (*Jun., Oct. 7, 1902*)	Feb. 6, 1907
Hunicke, William August. Constr. Engr., Cuban Cent. Rys., Ltd., Sagua la Grande, Cuba	Mar. 2, 1904
Hunt, Charles Adams. Asst. Div. Engr., Public Service Comm., 154 Nassau St., New York City	Oct. 4, 1905
Hunt, Leigh Anson. 911 Commerce Bldg., Kansas City, Mo	Feb. 6, 1907

	Date of Membership
Hunt, Loren Edward. Asst. Engr., Dept. of Public Works, 2639 Filbert St., San Francisco, Cal.	June 3, 1903
Hunter, John. Care, Brown-Hunter Co., 407 Dollar Bank Bldg., Youngstown, Ohio	Feb. 6, 1907
Hunter, Leroy Littlefield. Asst. Engr., Constr. Div., Bureau of Eng., 807 City Hall, Chicago, Ill. *(Jun., Jan. 5, 1904)*	Dec. 5, 1911
Hunter, Robert Easton. 2320 Mance St., Montreal, Que., Canada	Nov. 6, 1901
Hunter, Thomas Benton. Chf. Engr., Panama Calif. Exp. Co., 620 Timkin Bldg., San Diego, Cal. *(Jun., April 4, 1905)*	July 1, 1909
Hunting, Eugene Nathan. Reinforced Concrete Engr. for Nicola Bldg. Co., 2115 Farmers Bank Bldg., Pittsburgh, Pa. *(Jun., Nov. 1, 1904)*.	April 1, 1908
Huntington, George Danforth. Mgr., Detroit Office, Crosby Co., 717 Ford Bldg., Detroit, Mich.	Dec. 7, 1904
Huntington, Linn Murdoch. Ingeniero Encargado, Camino de Azua á San Juan, Obras Publicas de la Republica Dominicana, Azua, Santo Domingo. *(Jun., May 2, 1905)*	Aug. 31, 1909
Hurlbut, Charles Chase. Engr. with Kenneth M. Murchison, Archt., 298 Fifth Ave., New York City	Dec. 5, 1906
Hurlbut, Hinman Barrett. Engr. Expert Aid, Bureau of Yards and Docks, Navy Dept., Room 823, Mills Bldg., Washington, D. C.	July 1, 1909
Huston, Tillinghast L'Hommedieu. Habana 88, Havana, Cuba	May 2, 1900
Hutchings, John Bacon, Jr. Room 114, Eng. Hall, Univ. of Illinois, Urbana, Ill. *(Jun., Sept. 6, 1904)*	May 2, 1911
Hutchins, Edward. Box 255, Glens Falls, N. Y. *(Jun., June 6, 1905)*	Jan. 4, 1910
Hutchins, Harry Crocker. Asst. Engr., Bureau of Bldgs., 220 Fourth Ave. (Res., 15 West 107th St.), New York City. *(Jun., Mar. 1, 1910)*	Oct. 3, 1911
Hyatt, Caleb. Care, Harlem Contr. Co., 201st St. and Ninth Ave., New York City. *(Jun., Mar. 3, 1903)*	April 5, 1905
Hyde, John Lawrence. Town Engr., and Engr., Westfield Water-Works, Westfield, Mass.	July 10, 1907
Hyde, William Herbert. Contr., P. O. Box 791, Pittsburgh, Pa. *(Jun., April 30, 1901)*	June 4, 1902
Ichinose, Kyojiro. Dobokukyoku, Naimusho, Tokyo, Japan	Jan. 8, 1908
Ijams, Jesse Warren. Secy. and Gen. Mgr., Warren Eng. Co., 205 Opera House Blk., Terre Haute, Ind.	April 6, 1909
Ilsley, Arthur Benjamin. Engr. of Bridges, So. Ry., 1300 Penn. Ave., Washington, D. C. *(Jun., Feb. 28, 1899)*	Mar. 4, 1903
Immediato, Gerardo. Town Engr. (Res., 460 Bloomfield Ave.), Montclair, N. J.	July 9, 1906
Ingersoll, Charles Anthony. Engr. and Contr. (Barrally & Ingersoll), 853 Powers Bldg., Medina, N. Y.	Nov. 7, 1906
Ingram, Edward Lovering. Prof. of R. R. Eng. and Geodesy, Univ. of Pennsylvania, Philadelphia, Pa.	Sept. 4, 1895
Ingram, Willard Edward. Structural Engr., The Arnold Co., 105 South La Salle St., Chicago, Ill.	Oct. 2, 1907
Innes, Harry Clifford. Cons. Engr., Station R, Cincinnati, Ohio	Feb. 6, 1907
Insley, William Henry. Pres., Insley Mfg. Co., Indianapolis, Ind.	Aug. 31, 1909
Irish, Leland Wesley. Asst. Engr., Dept. of Highways, Albany, N. Y. *(Jun., Feb. 4, 1908)*	Feb. 1, 1910
Irwin, Orlando William. Designing Engr., Trussed Concrete Steel Co., 296 Pennsylvania Ave., Detroit, Mich. *(Jun., Sept. 4, 1906)*	Oct. 31, 1911
Ives, Howard Chapin. Cons. Engr.; Asst. Prof. of R. R. Eng., Worcester Polytechnic Inst., Worcester, Mass. *(Jun., Dec. 3, 1901)*	April 5, 1910
Jabelonsky, Carl Hugo. Cons. Engr. and Archt., 441 Peyton Bldg., Spokane, Wash. *(Jun., Sept. 1, 1903)*	June 6, 1911
Jackson, Granbery. Engr., International Agri. Corporation, 1109 Stahlman Bldg., Nashville, Tenn.	Jan. 4, 1905
Jackson, Jesse Aaron. Chf. Computer, City Engr.'s Office, Seattle, Wash.	Feb. 28, 1911
Jackson, John Franklin. Contr. Engr., Wisconsin Bridge & Iron Co., 605 Colby-Abbot Bldg., Milwaukee, Wis.	May 2, 1894
Jackson, Stuart Wilson. Asst. Engr., Pennsylvania State Highway Dept., Wellsboro, Pa.	April 4, 1911
Jacobosky, Gilbert Garfield. Cons. Engr., 116 Second National Bank Bldg., Wilkes-Barre, Pa. *(Jun., Nov. 5, 1907)*	June 6, 1911
Jacobs, Julius Lilien. Mgr., Houston and New Orleans Offices, James Stewart & Co., Contrs., 214 First National Bank Bldg., Houston, Tex. *(Jun., Sept. 1, 1908)*	Feb. 28, 1911
Jacobs, Robert Hyde. Senior Asst. Div. Engr., Public Service Comm., First Dist., 204 West 94th St., New York City	May 4, 1904

	Date of Membership
Jacobson, Alfred Leon. Chf. Engr., Edmond Coignet Reinforced Concrete Constructions, 28 Villa Dupont, 48 Rue Pergolese, Paris, France	April 5, 1910
Jahncke, Ernest Lee. Pres. and Mgr., The Jahncke Nav. Co., 814 Howard Ave., New Orleans, La	July 10, 1907
James, Alfred Randolph. Asst. Engr., Miraflores Locks and Dams, Corozal, Canal Zone, Panama	Nov. 8, 1909
James, Merton Earle. Barge Canal Office, Amsterdam, N. Y	Oct. 4, 1910
Janney, Thomas Gordon. Gen. Mgr., The Shasta Dredging Co., Larkin, Cal	Oct. 3, 1900
Jansen, Edward Clinton. Care, Central Colorado Power Co., 1210 Seventeenth St., Denver, Colo	May 3, 1905
Jaques, Jacob Duncan. Box 75, Woodbury, N. J	Nov. 1, 1910
Jarvis, Clarence Sylvester. U. S. Deputy Mineral Surv., Provo, Utah. (*Jun., Sept. 4, 1906*)	Sept. 5, 1911
Jenkins, James Edgar. Constr. Engr., Grant Smith & Co. & Locher, 25 West 42d St. (Res., 3440 Broadway), New York City	Dec. 5, 1906
Jennings, John Edward. 215 Westminster Rd., Brooklyn, N. Y	Nov. 30, 1909
Jensen, Christian Peter. City Engr., Fresno, Cal	Jan. 31, 1911
Jewett, John Young. Cement Expert, U. S. Reclamation Service, 408 Commonwealth Bldg., Denver, Colo	Sept. 6, 1910
Jewett, Thomas Edward. Vice-Pres., H. L. Stevens & Co., Houston, Tex.	Nov. 30, 1909
Johannesson, Sigvald. 149 Chestnut St., Montclair, N. J	Nov. 1, 1905
Johnson, Alexander. Cons. Engr., Dept. of Bridges, 13 Park Row, New York City	Sept. 5, 1900
Johnson, Charles. Asst. Engr., New Orleans Sewerage and Water Board (Res., 7925 Sycamore St.), New Orleans, La	Feb. 28, 1911
Johnson, Edwin Samuel. Mountain Park Land Co., Cheat Haven, Pa	Oct. 2, 1907
Johnson, George Arthur. Hydr. and San. Engr. (Johnson & Fuller), 150 Nassau St., New York City	Feb. 6, 1907
Johnson, George Rufus. 700 Washington Ave., West Haven, Conn	May 1, 1907
Johnson, Maro. Asst. Engr., Ill. Cent. R. R., 6549 Minerva Ave., Chicago, Ill	April 6, 1909
Johnson, Natt Madison. Superv. of Concrete, Gatun Locks, Gatun, Canal Zone, Panama	Oct. 4, 1910
Johnson, Rankin. 131 East 71st St., New York City	Feb. 7, 1900
Johnson, Robert Chan. Care, Canton-Samshui Line, Shekweitong, Canton, China	Feb. 1, 1910
Johnson, William Edward. Engr. in Chg. of Reservoirs, Hartford Water-Works, P. O. Box 382, West Hartford, Conn	April 3, 1901
Johnston, Charles Eugene. Chf. Engr., Kansas City South. Ry., Kansas City, Mo	June 1, 1909
Johnston, John Parry. Gen. Mgr., New York Engine Co., 165 Broadway, New York City. (*Assoc., April 3, 1894*)	Nov. 1, 1904
Johnston, Julius Gerardus. Address unknown	Feb. 6, 1907
Johnstone, William Bard. Cons. Engr., 1123 Broadway, New York City	May 4, 1904
Jones, Frederick Armistead. Care, Mo. & Kans. Telephone Co., Plant Dept., 10th and Grand, Kansas City, Mo	Nov. 8, 1909
Jones, Grandville Reynard. Chf. Chemist and Asst. Supt., Washington Aqueduct Filtration Plant, Washington, D. C. (*Jun., Jan. 7, 1908*)	May 2, 1911
Jones, Henry Llewellyn. Res. Engr., U. S. Steel Products Export Co., 30 Church St., New York City	Oct. 5, 1898
Jones, Jonathan. Engr., Pottstown Plant, McClintic-Marshall Constr. Co., Pottstown, Pa	Sept. 6, 1910
Jones, Robert Sharp. Chf. Engr., The James Westwater Co., Engrs. and Contrs., 501 Wyandotte Bldg., Columbus, Ohio	June 30, 1910
Jones, Samuel Reynolds. Structural Engr., J. G. White & Co., 43 Exchange Pl., New York City	April 6, 1909
Jones, Sidney Gardner. Asst. to Chf. Engr., M., St. P. & S. Ste. M. Ry., Soo Line, Gen. Offices (Res., 2408 First Ave., South), Minneapolis, Minn	Jan. 2, 1907
Jones, Thomas John. 95 Bellevue Ave., San Mateo, Cal	June 1, 1904
Jones, Walter Alpheus. Asst. Engr., L. V. R. R., Box 30, Weatherly, Pa.	Nov. 30, 1909
Jones, William Nelson. Supt. of Filtration Plant, Care, City Engr., Minneapolis, Minn	Oct. 31, 1911
Jonson, Ernst Fredrik. Engr. Insp., Board of Water Supply, 147 Varick St., New York City	Jan. 3, 1900
Jordahl, Anders. Gen. Mgr., Deutsche Kahneisengesellschaft, Jordahl & Co., Pottsdammerstr. 103^a, Berlin, Germany	Nov. 6, 1907
Jordan, William Frederick. Mgr., Grand Central Terminal Impvts., 124 Fisher Ave., White Plains, N. Y	April 1, 1891
Jorgensen, Lars Rasmus. Elec. and Hydr. Engr., 1406 Chronicle Bldg., San Francisco, Cal	May 4, 1909
Jouett, Henry Detrick. Designing Engr., N. Y. C. & H. R. R. R., 335 Madison Ave., New York City	Feb. 7, 1906

		Date of Membership
	Jubb, Sherman Augustus. Cons. Engr., 3151 California St., San Francisco, Cal.	Mar. 6, 1907
	Judd, Frank Rhymal. Chf. Draftsman, Bridge and Bldg. Dept., Ill. Cent. R. R., Room 1000, Park Row, Chicago, Ill.	Mar. 2, 1909
	Judell, Adolph. 20 Front St., San Francisco, Cal.	April 4, 1906
	Justice, Ged Hardy. Box No. 33, Hazard, Ky.	Sept. 5, 1911
	Justin, Joel DeWitt. Asst. Engr., New York Board of Water Supply, West Shokan, N. Y.	Oct. 3, 1911
	Kabashima, Masayoshi. Eng. Dept., City Hall, Tokyo, Japan	May 2, 1906
C.	Kahn, Julius. Care, Trussed Concrete Steel Co., Detroit, Mich. (*Jun., May 3, 1898*)	Oct. 3, 1900
	Kanary, Mark Henry. Pres., Rock Island Bridge & Iron Works, Rock Island, Ill.	May 3, 1910
	Karnopp, Edwin Benjamin. Div. Engr., Madeira-Mamoré R. R., Box 304, Manãos, Brazil. (*Jun., Jan. 3, 1907*)	Oct. 4, 1910
	Kast, Clarke Nightingale. Care, G. N. R. R., Princeton, B. C., Canada. (*Jun., June 4, 1901*)	June 7, 1905
	Kastenhuber, Edwin Gustav, Jr. Res. Engr., Easton Sewerage System, Box 244, Easton, Md.	July 1, 1909
	Kauffman, Vernet Albert. 1768 Emerson St., Denver, Colo. (*Jun., Feb. 3, 1903*)	July 10, 1907
	Kawaguchi, Torao. Koto Kogyogakko (Higher School of Technology), Kumamoto, Japan	Oct. 4, 1905
	Kays, Marion Reed. Chf. Engr., Idaho Irrig. Co., Ltd., Richfield, Idaho.	Dec. 6, 1910
	Keator, Edward Orris. Civ. Engr. and Contr., Cincinnati, Ohio	May 31, 1910
	Keays, Reginald Horton. Care, Degnon Contr. Co., New Paltz, N. Y. (*Jun., June 6, 1899*)	April 3, 1901
	Keim, Warren Byron. Asst. Engr., Bridge and Constr. Dept., The Pennsylvania Steel Co., Steelton (Res., Camp Hill), Pa.	Jan. 4, 1905
	Keith, Charles Whiteside. Bridge Engr., Bureau of Public Works, Manila, Philippine Islands	Mar. 7, 1906
	Keith, Lorin Acil. 226 W. 5th St., Mansfield, Ohio	Oct. 2, 1907
	Keller, Arthur Ripont. Care, Coll. of Hawaii, Honolulu, Hawaii	June 6, 1911
	Kelley, Matthew DeTobin. Cons. Engr., 142 South 6th St., Easton, Pa. (*Jun., Sept. 3, 1907*)	June 1, 1909
	Kelly, William. Capt., Corps of Engrs., U. S. A., U. S. Engr. Office, Manila, Philippine Islands	Feb. 3, 1904
	Kemp, John Edward. Civ. Engr., Kewanee Works, National Tube Co., Kewanee, Ill.	April 1, 1908
C.	Kempkey, Augustus. 721 Balboa Bldg., San Francisco, Cal. (*Jun., Mar. 31, 1903*)	Feb. 1, 1910
	Kern, Joseph Francis. Endicott Ave., Elmhurst, N. Y.	April 4, 1911
	Keys, Edward Allen. Special Insp. to the Secy. of the Interior, Room 227, Federal Bldg., Spokane, Wash.	July 9, 1906
	Kiehm, Charles. Mill Engr., 26 Gardiner Bldg., Utica, N. Y.	Jan. 8, 1908
	Killam, Charles Wilson. Asst. Prof. of Architectural Constr., Harvard Univ., 20 Walker St., Cambridge, Mass.	Dec. 4, 1907
	King, Clifford Marshall. City Engr., Sandusky, Ohio. (*Jun., Mar. 6, 1906*)	July 1, 1909
	King, Everett Edgar. Associate Prof. of Ry. Eng., Iowa State Coll., Ames, Iowa	Nov. 7, 1906
	King, Roy Stevenson. 612 Barnard St., Savannah, Ga.	Jan. 4, 1910
	Kingman, John Jennings. First Lieut., Corps of Engrs., U. S. A., 425 Custom House, Louisville, Ky.	April 4, 1911
	Kingsley, Edgar Albert. Supt. of Public Works, Little Rock, Ark.	Jan. 2, 1912
	Kinne, George Whitney. Erecting Dept., Am. Bridge Co. of N. Y., Room 209, Fuller Bldg., Jersey City, N. J.	Dec. 5, 1906
	Kinsey, William Ambrose. Contr. Engr., 192 Market St., Newark, N. J.	May 31, 1910
	Kirby, Isaac Henry. Roslyn, Nassau Co., N. Y.	Nov. 1, 1905
	Kirby, William Franklin. Williamson, W. Va.	Jan. 31, 1911
	Kirchner, Paul Alois. 40 West 36th St., New York City	Sept. 6, 1905
	Kirkham, John Edward. Associate Prof. in Civ. Eng., Iowa State Coll., 703 Kellog Ave., Ames, Iowa	Feb. 7, 1906
	Kirkpatrick, Harlow Barton. Care, James O. Heyworth, Harvester Bldg., Chicago, Ill.	Mar. 2, 1909
	Kissack, Alfred Broughton. Contr. Engr., The Midland Bridge Co., Sherman, Tex.	May 4, 1909
	Kittredge, Harry Chandler. Engr., 815 German Insurance Bldg., Rochester, N. Y.	Mar. 1, 1910
	Klein, Albert Robert. Chf. Engr., Constr. Dept., Bosch Magneto Co., Springfield, Mass.	Jan. 2, 1912
	Kleinschmidt, Henry Schwing. Cons. Engr., 1005 Newhouse Bldg., Salt Lake City, Utah. (*Jun., Mar. 1, 1904*)	Dec. 1, 1908
	Klossowski, Theodore Julius. 1211 Fifth Ave., Spokane, Wash.	April 6, 1904
	Klyce, Battle Hargrove. Box 240, Americus, Ga.	June 30, 1911

	Date of Membership
Knap, Edgar Day. Asst. Engr., Dept. of Bridges, 179 Washington St., Brooklyn, N. Y. (*Jun., Dec. 1, 1896*)	Dec. 4, 1900
Knight, Earle Kelly. 23 East 26th St., New York City	Dec. 4, 1907
Knight, Frank Barr. Chicago Mgr. and Engr., Lidgerwood Mfg. Co., 1917 Fisher Bldg., Chicago, Ill	Sept. 4, 1901
Knoch, Julius James. Prof. of Civ. Eng., Univ. of Arkansas, Fayetteville, Ark	Oct. 2, 1901
Koch, John Christian. Adjunct Prof. of Civ. Eng.; Road Specialist, Univ. of Georgia (Res., 287 Henderson Ave.), Athens, Ga	Jan. 4, 1910
Koenig, Arnold Charles. Cons. Engr., 554 Brandeis Theatre Bldg., Omaha, Nebr	Nov. 7, 1900
Kolb, Henry Jacob. Asst. Engr., Brooklyn Rapid Transit System, 85 Clinton St., Brooklyn, N. Y. (*Jun., Feb. 3, 1903*)	April 4, 1906
Koon, Joseph Burr. 2524 Thirty-eighth St., Chicago, Ill	May 3, 1910
Koon, Ray Emerson. Hydr. and San. Engr., 2524 Thirty-eighth St., Chicago, Ill	Oct. 7, 1908
Koss, George Walter. Contr. and Cons. Engr., 610 Securities Bldg., Des Moines, Iowa	June 6, 1911
Krafft, Alfred Julius. Engr., J. E. Krafft & Sons, Phelan Bldg., San Francisco, Cal	Jan. 2, 1912
Krause, Louis Gustav. Cons. Engr., 14 South Oakland Ave., Ventnor City, N. J	Jan. 2, 1912
Kreiner, Harry Peter. Surv. and Municipal Engr. (Borrie & Kreiner), 788 Broad St., Newark, N. J	Jan. 8, 1908
C. **Krellwitz, Diedrich William.** Asst. Engr., Public Service Comm., 103 East 125th St., Room 504, New York City. (*Jun., Oct. 31, 1905*)	Feb 2, 1909
Kreuger, Ivar. Contr. (Kreuger & Toll), Vasagatan 15, Stockholm, Sweden	Dec. 7, 1904
Krone, Arnold Henry. Director and in Chg., Eng. Dept. of J. Henry Miller, Inc., 106 Dover St., Baltimore, Md	May 31, 1910
Kuehnle, William Louis. U. S. Junior Engr., Room 710, Army Bldg., New York City	June 6, 1911
Kunkel, Julius Stephen. Care, Huastica Petroleum Co., Apartado 94, Tampico, Mexico	Feb. 28, 1911
Kyle, George Allen. Cons. Engr., 716 Spalding Bldg., Portland, Ore	Feb. 2, 1892
Kyle, Ralph Briggs. Engr. for Victor Marsh, Apartado 52, Ensenada, B. C., Mexico	May 3, 1910

Lafler, William Arthur. Cons. Engr., 214 Ellwanger & Barry Bldg., Rochester, N. Y	May 4, 1909
Lally, Thomas Edward. Asst. Engr., Water Service, Public Works Dept., Boston, Mass	May 2, 1911
Lamb, Ernest Avery. Res. Engr., Barge Canal Dredging Contracts, Sections Nos. 2 and 3, Res. Engr.'s Office, Guy Park House, Amsterdam (Res., 474 Madison Ave., Albany), N. Y	Sept. 7, 1904
Lamb, William Alfred. Dist. Engr., U. S. Geological Survey, Helena, Mont. (*Jun., Nov. 5, 1907*)	May 3, 1910
Lambert, Byron James. Prof. of Structural Eng., State Univ. of Iowa, Iowa City, Iowa	Jan. 5, 1909
Lambert, Wallace Corliss. Gleasondale, Mass	April 4, 1900
Lambie, Charles Sumner. Engr.-Contr., Tramway Bldg., Denver, Colo. (*Jun., Oct. 1, 1901*)	Feb. 6, 1907
Lamont, Clarence Booth. Asst. to the Pres., The Moran Co., 1103 Cherry St., Seattle, Wash	May 4, 1909
Lamson, William Mather. Asst. Engr., Board of Water Supply, 165 Broadway, Room 725, New York City	Sept. 5, 1911
Lanagan, Frank Ray. Deputy City Engr. (Res., 273 Hamilton St.), Albany, N. Y. (*Jun., Sept. 5, 1905*)	Feb. 1, 1910
Lancashire, Forest Henry. Designing and Const. Engr., Corpus Christi, Tex	July 10, 1907
Land, John Thomas. Asst. Engr., Seaboard A. L. Ry., P. O. Box 1228, Jacksonville, Fla	Oct. 4, 1910
Landers, Charles Scott. 149 Broadway, New York City	April 1, 1908
Lane, Edward Percy. Structural Engr., B. & M. R. R., North Station, Boston, Mass	Jan. 5, 1909
Lane, Edwin Grant. Care, Gen. Mgr.'s Office, B. & O. R. R., Baltimore, Md	Jan. 8, 1902
Lang, Frank August. Asst. Superv. Chf. Engr., U. S. Public Bldgs., 727 Custom House, New York City	Mar. 1, 1910
Lang, Philip George, Jr. Asst. Engr., Bridge Dept., B. & O. R. R., B. & O. Bldg., Baltimore, Md	Oct. 3, 1911
Lange, Theodore Ferdinand. Asst. Engr., N. Y. C. & H. R. R. R., 443 East 138th St., New York City	Feb. 5, 1908

	Date of Membership
Langley, Clarence Erwin. Junior Engr., Isthmian Canal Comm., Gatun, Canal Zone, Panama	Oct. 31, 1911
Lannan, Louis Edgar. Res. Engr., N. Y., W. & B. Ry., 105 Madison St. (Res., 132 Union Ave.), Mt. Vernon, N. Y.	June 7, 1905
Larkins, Edgar Ernest. Engr., Bridges and Sewers, City Engr.'s Office, Omaha, Nebr.	Sept. 6, 1910
Larmon, Frank Perry. Supt., The Lovejoy Co., Cambridge, N. Y.	July 9, 1906
Larrison, George Kirkpatrick. Care, U. S. Geological Survey, Washington, D. C.	July 1, 1908
Larson, Clarence Melrose. Asst. Engr., Railroad and Tax Commissions, 913 University Ave., Madison, Wis.	Oct. 7, 1908
LaRue, Eugene Clyde. Hydr. Engr., U. S. Geological Survey, Salt Lake City, Utah	Jan. 4, 1910
Lasley, Charles Orton. Engr., The A. Bentley & Sons Co., Gen. Contrs., Toledo, Ohio	May 4, 1904
Lathrop, Jay Cowden. Chf. Draftsman, Northern Ohio Power Co., 220 Hamilton Bldg., Akron, Ohio	Oct. 2, 1907
Laurgaard, Olaf. Chf. Engr., Columbia Southern Irrig. Project, 503 Couch Bldg., Portland, Ore.	June 1, 1909
Law, Walter Hills. With Holbrook, Cabot & Rollins Corporation, 6 Beacon St., Boston, Mass.	May 31, 1910
Lawrence, Charles Walter. Prof., Civ. Eng., Univ. of Southern California, 1203 W. 36th Pl., Los Angeles, Cal.	Jan. 8, 1908
Lawrence, Engelbert Conrad. Cons. Engr., Newport Contr. & Eng. Co., 428 East 22d St., Baltimore, Md.	Nov. 8, 1909
Lawson, Lawrence Milton. Asst. Engr., U. S. Reclamation Service, Yuma, Ariz.	Oct. 3, 1906
Lawton, Perry. 7 Savings Bank Bldg., Quincy, Mass. (*Jun., Jan. 3, 1893*).	Sept. 2, 1896
Lawton, Richard Mack. Asst. Engr., N. Y. C. & H. R. R. R., 335 Madison Ave., New York City	May 3, 1910
Lawton, Walter Luman. 85 West Cayuga St., Oswego, N. Y.	Mar. 5, 1902
Layng, Frank Rahn Shunk. Engr. of Track, B. & L. E. R. R., Greenville, Pa. (*Jun., April 1, 1902*)	May 3, 1910
Leahy, Maurice Joseph. South Hadley Falls, Mass.	Dec. 4, 1907
Leake, Boudinot Gage. Civ. Engr. and Archt., Room 20, Dundee Bldg., Fort Worth, Tex. (*Jun., Jan. 5, 1904*)	May 3, 1905
Leane, Walter Burditt. Chf. Engr., Ferrocarril Longitudinal, Seccion Norte, Agustinas 718, Santiago, Chili	Jan. 3, 1906
Lee, Augustine Leftwich. Asst. Engr., Am. Bridge Co., Ambridge, Pa.	Oct. 3, 1906
Lee, Charles Avery. Asst. Engr., Vancouver Power Co., Vancouver, B. C., Canada	Oct. 31, 1911
Lee, Charles Hamilton. Asst. Engr., Bureau of Los Angeles Aqueduct Power, 1134 Central Bldg., Los Angeles, Cal. (*Jun., Jan. 2, 1906*)	Jan. 31, 1911
Lee, Elsworth Mortimer. Engr. and Archt. (Lee & Hewitt), 1123 Broadway, New York City	Mar. 7, 1906
Lee, Engbert A. Engr., Am. Smelting & Refining Co., Perth Amboy, N. J.	Oct. 7, 1903
Lee, John Louis. 472 Edwards St., Oakland, Cal.	April 3, 1907
Lee, Robert Hileman. Asst. Bridge Engr., Bridge Dept., Cuyahoga County, 2216 Bellfield Ave., Cleveland Heights, Ohio. (*Assoc., May 2, 1906*)	June 6, 1911
Leeds, Charles Tileston. Capt., Corps of Engrs., U. S. A., Fort Bayard, N. Mex. (*Jun., Jan. 3, 1907*)	April 4, 1911
Leefe, Frederick Ewbank. U. S. Junior Engr., U. S. Engr. Office, Marshfield, Ore.	May 6, 1908
Leeper, John Bigger. Asst. Engr., Am. Bridge Co., Frick Bldg., Pittsburgh, Pa.	Jan. 3, 1900
Leete, Percy Remington. Res. Engr., N. Y., N. H. & H. R. R., Botsford (Res., 1022 Norman St., Bridgeport), Conn.	Feb. 28, 1911
Leeuw, Henry Alexander. Mgr., Glyndon Contr. Co., Yorktown Heights, N. Y. (*Jun., Sept. 5, 1905*)	Oct. 5, 1909
Lemen, William Caswell Smith. U. S. Asst. Engr., U. S. Engr. Office, Brunswick, Ga.	July 10, 1907
Letson, Thomas Herbert. 39 Cortlandt St., New York City. (*Assoc., Mar. 1, 1905*)	Oct. 2, 1906
Levy, Alfred. New Works Engr., Ferrocarril Central Dominicano, Puerto Plata, Santo Domingo	Dec. 5, 1911
Lewis, Arthur Stephen. Secy. and Supt., Lincoln Park, Chicago, Ill.	April 6, 1909
Lewis, Clarence McKenzie. Care, Wm. Salomon & Co., 25 Broad St., New York City	Dec. 3, 1902
Lewis, Clifford, Jr. Second National Bank Bldg., Utica, N. Y.	Sept. 2, 1903
Lewis, John Howard. State Engr., Salem, Ore.	Sept. 6, 1905
Lewis, John Ovington. 347 Twenty-first St., Brooklyn, N. Y.	Jan. 2, 1912
Lewis, Luther Hammond. Archt., 200 Fifth Ave., New York City	April 6, 1904
Lewis, Ransome Tedrowe. Mgr., Elmira Plant, Empire Bridge Co., Elmira, N. Y.	June 6, 1906
Lewis, Walter Raleigh. Supt., Water-Works, City Hall, Trinidad, Colo.	May 3, 1905

	Date of Membership
Lex, Washington Irving. 1508 N. 19th St., Philadelphia, Pa.	May 2, 1906
Lichtner, William Otto. Asst. to Sanford E. Thompson, Newton Highlands, Mass. (*Jun., Aug. 31, 1909*)	Jan. 2, 1912
Lightfoot, William Joseph. U. S. Surv. and Special Disbursing Agt., Dept. of the Interior, Care, U. S. Surveyor General, San Francisco, Cal.	Feb. 1, 1905
Linard, Drew Jones. 116 Masonic Temple, Mobile, Ala.	July 10, 1907
Lincoln, Levi Bates. Locating Engr., B. & A. R. R., Houlton, Me.	Jan. 3, 1911
Lincoln, Samuel Bicknell. Engr., Chicago Office, Lockwood, Greene & Co., 937, First National Bank Bldg., Chicago, Ill.	Dec. 5, 1911
Lindau, Alfred Emanuel. Chf. Engr., Corrugated Bar Co., New Bank of Commerce Bldg., St. Louis, Mo.	Jan. 3, 1906
Lindhé, John Birger. Civ. Engr., U. S. Engr. Dept., Burrwood, La.	Nov. 4, 1908
Lindholm, Carl Bertram. (Lindholm & Tuller), Agri. National Bank Bldg., Pittsfield, Mass.	April 6, 1909
Lindsey, Kieffer. Civ. and Constr. Engr., 1 Third Ave., Rome, Ga. (*Jun., Oct. 7, 1902*)	Oct. 4, 1905
Lineberger, Walter Franklin. Tech. Director, Compañia Minera San Mateo, S. A.; Cons. Engr., Apartado 333, Torreón, Coahuila, Mexico.	May 4, 1909
Linnell, Herbert Prescott. Chf. Engr., Atlantic, Gulf & Pacific Co., Manila, Philippine Islands	May 2, 1906
Linton, Walter Powell. 434 South 40th St., Philadelphia, Pa.	June 6, 1911
Little, George Kerr. U. S. Asst. Engr., Tuscaloosa, Ala.	June 3, 1903
Livermore, Norman Banks. Pres., Norman B. Livermore & Co., Metropolis Bank Bldg., San Francisco, Cal. (*Jun., Dec. 5, 1899*)	Oct. 1, 1902
Lobo, Carlos. Asst. Engr., Dept. of Water Supply, Borough of Brooklyn, Municipal Bldg. (Res., 550 Seventh St.), Brooklyn, N. Y.	May 3, 1905
Locke, William Willard. San. Insp., Met. Water and Sewerage Board, 4 Evergreen St., South Framingham, Mass.	Oct. 6, 1897
Lockwood, Richard John. Chf. Engr., New Iberia & North. R. R., New Iberia, La.	May 3, 1910
Loewenstein, Jacob. Am. Bridge Co., 30 Church St. (Res., 2 West 94th St.), New York City	Feb. 6, 1907
Logan, William Seeley. Cons. Engr. and Surv., 9 Clinton St., Newark, N. J.	April 6, 1904
Long, Clarence Burton. Asst. Engr., U. S. Reclamation Service, Augusta, Mont.	Nov. 8, 1909
Long, Eugene McLean. Cons. Engr. (Long & Miller), 220 Broadway, New York City	June 1, 1898
Long, John Coleman. Long Constr. Co., 3332 Summit St., Kansas City, Mo.	Jan. 8, 1908
Longley, Francis Fielding. Res. Engr., Toronto Filtration Plant, Toronto, Ont., Canada. (*Jun., Feb. 28, 1905*)	Mar. 2, 1909
Louckes, Frank Irwin. Junior Engr., U. S. Engr. Office, Box 72, Louisville, Ky.	Jan. 3, 1911
Loughran, Harold Scott. Prin. Asst. Engr. with L. E. Van Etten, Hillcrest Ave., New Rochelle, N. Y. (*Jun., Jan. 2, 1906*)	Jan. 2, 1912
Loughran, James Francis. County Supt. of Highways, Ulster Co., 44 Main St., Kingston, N. Y. (*Jun., Feb. 4, 1908*)	Dec. 5, 1911
Louwerse, Peter Martin. Trussed Concrete Steel Co., 145 Euclid Ave., West, Detroit, Mich.	April 1, 1908
Love, Andrew Cavitt. Supt., Beaumont Irrig. Co., Beaumont, Tex.	Feb. 6, 1907
Lovell, Earl Brink. Prof., Civ. Eng., Columbia Univ.; Vice-Pres., Chas. Hansel & Co.; Mgr., Eng. Dept., Lawyers Title Insurance & Trust Co., New York City	April 4, 1906
Lovett, George Frederick. Constr. Engr., Berlin Mills Co., Berlin, N. H.	Sept. 7, 1904
Low, George Evarts. 45 Broadway, New York City. (*Jun., Nov. 6, 1894*)	Mar. 2, 1898
Lowinson, Oscar. Cons. Archt. and Engr., 18 East 42d St., New York City. (*Jun., May. 3, 1892*)	Feb. 7, 1900
Lowther, Burton. Const. Engr., Water-Works Dept., 2608 Brooklyn Ave., Kansas City, Mo.	Oct. 7, 1908
Lucas, George Latimore. Gen. Insp. of Material, Public Service Comm., First Dist., 154 Nassau St., New York City	Dec. 7, 1904
Ludlow, Justin Wyman. Asst. Prof. of Structural Eng., Lewis Inst., Chicago, Ill. (*Jun., April 5, 1904*)	Mar. 1, 1910
Ludwig, Julius Alfred. 79 Wall St., New York City. (*Jun., May 31, 1892*)	Oct. 2, 1895
Lund, George Alfred. Mgr., Post & McCord, 44 East 23d St., New York City	Nov. 7, 1894
Lund, Robert Leathan. Cons. Engr., 5968 W. Cabanne Pl., St. Louis, Mo.	May 4, 1904
Lundoff, Clemens Waldemar. Vice-Pres., Crowell & Sherman Co., 3111 Carnegie Ave., Cleveland, Ohio	June 3, 1908
Lush, Cuyler Warfield. Knickerbocker Bldg., Baltimore, Md. (*Jun., Feb. 4, 1908*)	May 31, 1910
Lyle, William Thomas. Prof. of Municipal Eng., Lafayette Coll., Easton, Pa.	Nov. 6, 1901

	Date of Membership
Lyman, Richard Roswell. Cons. Engr.; Prof. of Civ. Eng., Univ. of Utah; Vice-Chairman, State Rd. Comm., Salt Lake City, Utah. (*Assoc., May 4, 1904*)	Feb. 2, 1909
Lynch, Tillman Danis. Research Engr., Westinghouse Elec. & Mfg. Co., 816 Wallace Ave., Wilkinsburg, Pa.	Nov. 3, 1897
Lyon, Wallace Chittendon. Asst. Structural Engr., Care, Superv. Archt.'s Office, Washington, D. C.	Feb. 6, 1901
Lytel, James Leonard. Project Engr., Strawberry Val. Project, U. S. Reclamation Service, Provo, Utah	Jan. 4, 1905
Macartney, Morton. City Engr., 3214 Glass Ave., Spokane, Wash.	Mar. 2, 1909
MacCornack, Clyde Webster. Asst. Engr., Phœnix Bridge Co., 324 Gay St., Phœnixville, Pa. (*Jun., Jan. 31, 1905*)	Dec. 1, 1908
MacCracken, George Gere. 559 Fifth Ave., New York City. (*Jun., Feb. 5, 1901*)	Feb. 3, 1904
MacCrea, Don Alexander. Cons. Engr. (Ford & MacCrea), Room 338, Gazette Bldg., Little Rock, Ark. (*Jun., May 2, 1899*)	Oct. 1, 1902
Macdonald, Archibald Angus. Archt., 550 West 41st St., New York City. (*Jun., June 4, 1901*)	Oct. 5, 1904
MacFeeters, John Orr. Asst. Engr., Am. Bridge Co., 4619 Eleventh Ave., Brooklyn, N. Y.	Oct. 3, 1911
MacGregor, John Grant. Chf. Engr., Alberta Cent. Ry., Red Deer, Alta., Canada	June 3, 1903
Mack, Edward R. Supt. of Parks, 806 Van Buren St., Wilmington, Del.	June 7, 1905
Mackall, John Nathaniel. Asst. Engr., State Roads Comm. of Maryland, Baltimore, Md. (*Jun., Aug. 31, 1909*)	June 30, 1911
Maclay, Edgar Gleim. Chf. Engr., The Am. Constr. Co., 9th Floor, Carter Bldg., Houston, Tex.	Oct. 3, 1906
Macnab, George Travilla. Asst. Engr., Highways, Borough of the Bronx, 311 West 95th St., New York City	Feb. 3, 1897
MacNair, Henry James. Editor, Automobile Blue Book, Broadway and 76th St., New York City	June 1, 1904
MacNaughton, Ernest Boyd. Pres. and Mgr., MacNaughton & Raymond, Inc., Archts.-Engrs., 606 Concord Bldg., Portland, Ore.	Oct. 7, 1908
Macomb, John de Navarre, Jr. Asst. Engr., A., T. & S. F. Ry. System, General Offices, Topeka, Kans.	Oct. 5, 1904
Macredie, John Robert Clarke. Box 72, Outlook, Sask., Canada	Feb. 28, 1911
Macy, Elbert Clyde. Supt. of Constr., Stone & Webster Eng. Corporation, Bellingham, Wash.	Sept. 2, 1903
McCausland, Charles Patterson. Locating Engr., West. Md. Ry., Box 250, Cumberland, Md.	Dec. 6, 1910
McClelland, Claude Leslie. 330 West G St., Ontario, Cal.	Oct. 7, 1908
McClintock, James Robinson. With George W. Fuller, 170 Broadway, New York City. (*Jun., Oct. 2, 1906*)	May 3, 1910
McClure, Guy Vincent. City Engr., City Hall, Oklahoma, Okla.	April 4, 1911
McConnell, Ira Welch. Vice-Pres. and Gen. Mgr., Idaho Irrig. Co., Ltd., Richfield, Idaho	Dec. 7, 1904
McConnell, John Lorenzo. 1514 East 54th St., Chicago, Ill. (*Jun., April 4, 1905*)	Jan. 2, 1907
McCord, James Benney. Bessemer Bldg., Pittsburgh, Pa.	Jan. 2, 1907
McCormick, Herbert Granville. Junior Engr., U. S. Engr. Office, Frankfort, Ky.	April 1, 1908
McCoy, Charles Ephraim. Care, Kanawha National Bank, Charleston, W. Va.	June 3, 1903
McCulloch, Richard. Asst. Gen. Mgr., United Rys. Co. of St. Louis, 3869 Park Ave., St. Louis, Mo.	Mar. 2, 1898
McCurdy, Harry Sherwood Royden. Div. Engr., Board of Water Supply of City of New York, Brown Station, N. Y.	Sept. 7, 1904
McDargh, Harry John. 6558 Ellis Ave., Chicago, Ill.	April 2, 1902
McDermith, Oro. Asst. Engr., U. S. Reclamation Service, Newell, S. Dak.	June 6, 1911
McDonald, Harry L. Asst. Topographer, U. S. Geological Survey, Wenatchee, Wash.	Oct. 31, 1911
McDonough, Michael Joseph. Capt., Corps of Engrs., U. S. A., Fort Santiago, Manila, Philippine Islands	Jan. 2, 1907
McGeehan, Paul. Engr. in Chg., Sewer Div., City Engr. Dept., Kansas City, Mo.	July 10, 1907
McGlashan, Harry Deyoe. Dist. Engr., U. S. Geological Survey, 505 U. S. Custom House, San Francisco (Res., 2315 Hilgard Ave., Berkeley), Cal.	Oct. 31, 1911
McGlathery, Sam Lyon. Pass Christian, Miss.	Feb. 28, 1911
McGregor, Robert Roy. Asst. Engr., S. P. Co., Rocklin, Cal.	Mar. 6, 1907
McHarg, Leslie. Contr., 165 Broadway, New York City. (*Jun., Mar. 5, 1901*)	April 6, 1909
McIntyre, William Ainsworth. Engr. and Supt. of Highways, Lower Merion Township, Montgomery County, 152 Land Title Bldg., Philadelphia, Pa.	Feb. 6, 1912

	Date of Membership
McKenzie, Andrew Jackson. City Engr. and Street Commr., Webb City, Mo.	Dec. 5, 1911
McKenzie, Thomas. Westerly, R. I. *(Jun., May 2, 1893)*	Nov. 6, 1895
McLachlan, Duncan William. Dept. of Railways and Canals, Ottawa, Ont., Canada	Dec. 6, 1910
McLean, Joseph Patton. 68 Garrison Ave., Jersey City, N. J.	Mar. 2, 1904
McLoughlin, Joseph Navarre. Asst. Supt., Montana Div., Ore. Short Line R. R., Pocatello, Idaho	Nov. 1, 1910
McLure, Norman Roosevelt. Prin. Asst. Engr., The Phœnix Iron Co., Phœnixville, Pa. *(Jun., Feb. 6, 1906)*	Nov. 4, 1908
McMeekin, Charles William. Gen. Mgr., Crœsus Gold Min. & Milling Co., Plumbago, Alleghany P. O., Sierra Co., Cal. *(Jun., April 2, 1890)*	Mar. 7, 1894
McMenimen, William Vincent. 172 Fairview Ave., Jersey City, N. J. *(Jun., April 30, 1907)*	May 31, 1910
McMorrow, James Walter. Secy., McMorrow Eng. & Constr. Co., 3785 Broadway (Res., 550 West 157th St.), New York City	Oct. 7, 1908
McNary, Joseph Vance. Asst. Engr. in Chg. of Bridge Constr., Dept. of Public Works, Bureau of Constr., Pittsburgh, Pa	June 30, 1910
McNeil, Arthur James. Res. Engr., Central Fuel Oil Co., Bartlesville, Okla. *(Jun., Mar. 6, 1906)*	Mar. 1, 1910
Madden, John Henry. Asst. Div. Engr., Public Service Comm., First Dist., 515 West 111th St., New York City. *(Jun., Oct. 7, 1902)*	May 4, 1904
Magor, Henry Basil. Pres., Magor Car Co., 50 Church St., New York City. *(Jun., April 30, 1895)*	Mar. 7, 1900
Magruder, Frank Cecil. Engr., U. S. Reclamation Service, Belle Fourche, S. Dak. *(Jun., Sept. 6, 1904)*	Oct. 4, 1910
Mahon, Ross LeHunt. Care, Riverside Printing Co., Port Huron, Mich.	Feb. 1, 1910
Maier, Harry Ludwig. Asst. Engr., Street and Sewer Dept., 229 Connell St., Wilmington, Del	June 5, 1907
Mair, John William. 49 North High St., Columbus, Ohio	April 1, 1908
Malcolm, Charles Wesley. Asst. Prof. of Structural Eng., Univ. of Illinois, 908 W. Nevada St., Urbana, Ill. *(Jun., Sept. 4, 1906)*	April 6, 1909
Malcolm, William Duncan. Res. Engr., Henry Steers, Inc., 17 Battery Pl., New York City (Res., 250 North 11th St., Newark, N. J.)	Dec. 5, 1911
Malukoff, Alexis Joseph. Asst. Engr., Dept. of Bridges, Park Row Bldg., (Res., 213 West 136th St.), New York City	Jan. 2, 1901
Manning, James Henry. Stone & Webster Eng. Corporation, 147 Milk St., Boston, Mass	Jan. 3, 1911
Manning, William Sheppard, Jr. The Solvay Process Co., Syracuse, N. Y.	Sept. 6, 1905
Mansfield, Royal John. 49 Claremont Ave., New York City. *(Jun., Dec. 2, 1902)*	July 10, 1907
Mapes, Charles Maynard. Smith Bldg., 148th St. and Third Ave., New York City	July 10, 1907
Markwart, Arthur Hermann. (Galloway & Markwart), First National Bank Bldg., San Francisco, Cal	July 9, 1906
Marquand, Philip. 2730 Belrose Ave., Berkeley, Cal	Oct. 5, 1898
Marsh, Francis Beal. Asst. Engr., Board of Water Supply, 165 Broadway, New York City. *(Jun., Oct. 2, 1906)*	Jan. 3, 1911
Marshall, Cyril Ernest Davis. Garden City, N. Y.	Mar. 6, 1907
Marshall, Thomas Clawson. Field Engr., B. & O. R. R., 808 Fourth Ave., Huntington, W. Va	May 4, 1909
Marshall, Thomas Worth. Cons. Engr., 729 Fifteenth St., N. W., Washington, D. C.	June 3, 1908
Marshall, Urban Serenus. (Phinney, Cate & Marshall), Forum Bldg., Sacramento, Cal	Feb. 1, 1910
Martin, Bertrand Clifford. Asst. Dist. Engr., N. Y. C. & H. R. R. R., 187 Oneida St., Utica, N. Y.	May 4, 1909
Martin, John. Engr. of Maintenance, Borough of the Bronx, Room 3, Third Ave. and 177th St., New York City	May 31, 1910
Martin, Richard Herbert. Prin. Asst. Engr., Florida East Coast Ry., P. O. Box 143, St. Augustine, Fla.	Oct. 4, 1910
Martin, Walter Irving. Barrington, Ill	April 1, 1908
Martin, William Franklin. Dist. Engr., U. S. Geological Survey, Executive Bldg., Honolulu, Hawaii. *(Jun., Mar. 5, 1907)*	Feb. 1, 1910
Martinez y Reugifo, Conrado Eugenio. 107 San Miguel St., Havana, Cuba.	Oct. 7, 1908
Mason, Frank Henry. Chf. Engr., Central Maine Power Co., Waterville, Me.	Oct. 3, 1911
Mason, Samuel Jefferson. City Surv.; (Mason & Smith), 102 Smith St., Perth Amboy, N. J.	Jan. 8, 1908
Massenburg, Walter Gray. Div. Engr., G. C. & S. F. Ry., Beaumont, Tex.	Jan. 2, 1907
Matheson, Ernest George. 409 West 129th St., New York City	June 1, 1904
Matheson, John Douglas. Representative, Warren & Wetmore, Archts., New Union Terminal, Winnipeg, Man., Canada. *(Jun., Mar. 3, 1903)*	May 1, 1907
Matlaw, Isaac Solon. Asst. Engr., Bureau of Locks, Barge Canal Office, Lyon Blk., Albany, N. Y. *(Jun., Oct. 2, 1906)*	July 1, 1909
Matson, Jesse Sidwell. County Engr., Jefferson, Ohio	July 1, 1908

	Date of Membership
Matthes, François Emile. Topographic Insp., U. S. Geological Survey, Washington, D. C.	April 3, 1901
Maughmer, Carl. Chf. Asst., Div. No. 2, State Highways, Redding, Cal.	Jan. 4, 1910
Maupin, Edgar Staples. 1200 Grove St., Vicksburg, Miss. (*Jun., Sept., 5, 1905*)	Nov. 8, 1909
Mawson, George Thomas. Chf. Asst. Engr. and Archt., Marsland, Price & Co., Ltd., Watson's Annex Chambers, Bombay, India	June 30, 1911
Mayell, Albert Jefferson. Asst. Engr., Public Service Comm., First Dist., 154 Nassau St. (Res., 322 East 198th St.), New York City. (*Jun., Mar. 1, 1904*)	Oct. 3, 1911
Mayhew, Alfred Boardman. Asst. Engr., U. S. Reclamation Service, Arrowrock, Idaho	Nov. 8, 1909
Meadowcroft, William. Asst. Engr. (Designer), Board of Water Supply, 165 Broadway, New York City	Dec. 6, 1905
Means, Howard Chester. Supt. of Irrig., U. S. Indian Service, Myton, Utah.	June 30, 1910
Mears, Frederick. Chf. Engr., Panama R. R., Cristobal, Canal Zone, Panama	Feb. 1, 1910
Mechlin, Oscar Alexander. Asst. Prof., Civ. Eng., George Washington Univ.; Architectural Engr. (Mechlin & Starr), 3203 R St., Washington, D. C.	Sept. 5, 1911
Meek, Gordon Stafford. Supt., Penn. & Lake Erie Dock Co., Fairport Harbor, Ohio	Oct. 4, 1905
Meem, James Lawrence. Night Supt., Grant Smith & Co. & Locher, Rome, N. Y.	Oct. 4, 1910
Meggy, Robert Louis Gurdelston. North Ave. and Russell Rd., Fanwood, N. J.	Feb. 6, 1907
Melick, Neal Albert. Supt. of Constr., U. S. Public Bldgs., Granite City, Ill. (*Jun., Dec. 2, 1902*)	July 9, 1906
Melius, Ludlow Lawrence. Care, Spuyten Duyvil Constr. Co., 271 West 125th St., New York City. (*Jun., May 2, 1899*)	Dec. 6, 1905
Melluish, James George. Civ. and San. Engr., 222 Unity Bldg., Bloomington, Ill.	June 7, 1905
Melton, Arthur Pomeroy. Cons. Engr. and City Engr., Gary, Ind.	Sept. 5, 1911
Merrick, Howard B. Asst. Prof. of Surveying, Univ. of Michigan, 928 Church St., Ann Arbor, Mich.	July 1, 1909
Merrill, Farrand Seymour. Designing Dept., Am. Bridge Co., 1421 Frick Bldg., Pittsburgh, Pa.	April 5, 1910
Merrill, Ogden. Pres., Merrill-Ruckgaber Co., 50 Church St., New York City	Feb. 3, 1904
Merrill, Oscar Charles. Chf. Engr., U. S. Dept. of Agri., Forest Service, 1025 First National Bank Bldg., San Francisco, Cal.	April 6, 1909
Merriman, Fred Knights. Instr. in Chg., Civ. Eng. Dept., Catholic Univ. of America, Washington, D. C.	June 30, 1911
Metzger, Fritz Louis. Civ. Engr., Cummings Structural Concrete Co., Pittsburgh, Pa. (*Jun., Feb. 6, 1906*)	Jan. 31, 1911
Metzger, Louis Charles Frederick. Asst. Engr., Terminal R. R. Assoc. of St. Louis, 2650 Accomac St., St. Louis, Mo.	May 31, 1910
Meyer, Adolph Frederick. U. S. Junior Engr., Box 654, St. Paul, Minn.	Jan. 31, 1911
Meyers, Alfred Moyer. Architectural Engr., Kansas City Structural Steel Co., Kansas City, Mo.	Oct. 5, 1904
Meyers, Clarence William. Asst. Engr., Rapid Transit Subway Constr. Co., 314 Riverside Drive, New York City. (*Jun., Sept. 1, 1903*)	Oct. 2, 1907
Middleton, Robert James. Asst. Engr., B. and B. Dept., C., M. & St. P. Ry., 1449 Granville Ave., Chicago, Ill.	Dec. 4, 1907
Miles, George Frederick. Cons. Efficiency Engr., 108 Worth St., New York City	June 30, 1911
Millard, William John. Kanyama, Manyiema, Kinshasa, Congo Belge, West Africa. (*Jun., Nov. 30, 1909*)	June 6, 1911
Miller, Clifford Neville, 24 Waterworks Bldg., Kansas City, Mo. (*Jun., June 4, 1891*)	Feb. 5, 1896
Miller, Crosby. Asst. Engr., Estimating Dept., Bridge and Constr. Dept., Pennsylvania Steel Co., Steelton, Pa. (*Jun., Jan. 7, 1908*)	Jan. 3, 1911
Miller, Edward Thomas Every. Ingeniero Seccional, Ferro Carril Central Argentino, Cordoba, Argentine Republic	Dec. 5, 1911
Miller, George Soter. Vice-Pres. and Treas., G. H. Anson & Co., Ltd., 16 Bank of Toronto Chambers, Montreal, Que., Canada	April 1, 1903
Miller, Hiram. 102 Carmel St., New Haven, Conn.	Jan. 5, 1909
Miller, Lee Haun. Care, Bethlehem Steel Co., 1264 Ontario St., Cleveland, Ohio	Jan. 31, 1911
Miller, Max Merrill. Designer, Bridge Dept., N. Y. C. & H. R. R. R., 335 Madison Ave., New York City (Res., Puritan Ave., Colonial Heights, Yonkers, N. Y.)	Oct. 7, 1908
Miller, Stanley Alfred. 1800 Monroe St., Paducah, Ky. (*Jun., Feb. 4, 1902*)	April 6, 1909
Miller, Walter Edward. Civ. Engr. Insp., R. R. Comm. of Wisconsin, Madison, Wis.	May 31, 1910

	Date of Membership
Miner, James Henry. Project Engr., U. S. Reclamation Service, Grand Junction, Colo. (*Jun., Mar. 31, 1903*)	Nov. 8, 1909
Minniss, George Stewart. (Ricker & Minniss), 702 Ellicott Sq., Buffalo, N. Y.	Dec. 5, 1906
Minor, Cyrus Edward. Asst. Engr. for Cananea Consolidated Copper Co., Box 150, Cananea, Sonora, Mexico	May 31, 1910
Mirick, Alfred Stowe. Asst. Engr., New York State Dept. of Highways, 144 Jay St., Albany, N. Y.	Oct. 5, 1909
Mitcham, George Nathan. Prof. of Civ. Eng., Alabama Polytechnic Inst., Auburn, Ala.	Nov. 8, 1909
Mitchell, Lester Hale. Care, U. S. Reclamation Service, Glendive, Mont.	Oct. 5, 1909
Mitchell, Louis Adolph. Supt. of Roadway and Bldgs., Indiana Union Traction Co., Anderson, Ind.	May 31, 1910
Mobberly, Henry Peyton. Chf. Engr., Paris & Mt. Pleasant R. R., Paris, Tex.	April 3, 1907
Moler, William Griffith. Mgr., Eastern Div., Corrugated Bar Co., 17 Battery Pl., New York City	Jan. 3, 1900
Móller, Louis. Thunder Bay Contr. Co., Port Arthur (Res., 132 Harold St., Fort William), Ont., Canada	May 1, 1907
Moncur, George. Prof. of Civ. Eng., Glasgow Technical Coll., Glasgow, Scotland	June 6, 1911
Mönniche, Tollef Bache. Designing Engr., Isthmian Canal Comm., Culebra, Canal Zone, Panama	Oct. 3, 1906
Monsarrat, Nicholas Daubeney. Second Vice-Pres., Sunday Creek Co., Outlook Bldg., Columbus, Ohio. (*Jun., Feb. 5, 1895*)	Sept. 2, 1903
Montero, Julio Daniel. Chf. Engr., Bureau of Roads and Bridges, Salud No. 97 altos, Havana, Cuba. (*Jun., Oct. 1, 1907*)	Feb. 28, 1911
Montgomery, Ernest. Supt. of Constr., Southern Alberta Land Co., Suffield, Alta., Canada	Oct. 5, 1909
Moody, Clare Joseph. Asst. Engr., U. S. Reclamation Service, Ronan, Mont.	June 6, 1911
Moody, Joseph Elbert. With Hurley, Mason Co., Engrs. and Contrs., Tacoma, Wash.	Oct. 7, 1908
Moore, Lewis Eugene. Asst. Prof. of Civ. Eng., Mass. Inst. Tech., 85 Washington Park, Newtonville, Mass. (*Assoc., April 1, 1908*)	April 5, 1910
Moorehead, Theodore Parker. Vice-Pres., H. L. Stevens & Co., 120 Pacific Bldg., Vancouver, B. C., Canada	Oct. 5, 1909
Moorshead, Alfred Lee. Res. Engr., Bergen Hill Cut, Erie R. R., 649 Summit Ave., Jersey City (Res., 49 Locust Ave., Arlington), N. J.	April 3, 1907
Moorshead, Oliver. 311 West Broadway, Newton, Kans.	May 31, 1910
More, Charles Church. Box 26, Hamilton Grange Sta., New York City. (*Jun., May 2, 1899; Assoc., Feb. 6, 1907*)	Mar. 31, 1908
Morey, Richard. Pres., Morey-Faulhaber Constr. Co., Chemical Bldg., St. Louis, Mo.	Jan. 2, 1901
Morgan, Arthur Ernest. Pres., Morgan Eng. Co., 608 Goodwyn Inst. Bldg., Memphis, Tenn.	May 3, 1910
Moritz, Ernest Anthony. Engr., U. S. Reclamation Service, Helena, Mont. (*Jun., Oct. 6, 1908*)	Jan. 4, 1910
Morrill, Wilbur Nathaniel. Managing Engr. for The Weber Co., Room 206, Courier Journal Bldg., Louisville, Ky.	Jan. 8, 1908
Morris, Charles Chester. Junior Engr., U. S. A., Care, U. S. Engr. Office, Corregidor, Philippine Islands	Oct. 3, 1911
Morrison, Charles Edward. 50 Pine St., New York City	Oct. 5, 1909
Morrison, George Eldridge. 1015 Douglas Ave., East Las Vegas, N. Mex.	Nov. 1, 1910
Morrison, James Luther. (Morrison Bros.), Hazard, Ky.	Nov. 4, 1908
Morrison, Thomas Edward. Engr., Stupp Bros. Bridge & Iron Co., St. Louis, Mo.	Oct. 3, 1911
Morrow, Frederick Edgar. Office Engr., C. & W. I. R. R., Dearborn Station (Res., 423 North Central Ave.), Chicago, Ill.	Nov. 8, 1909
Morse, Howard Scott. 1112 Tremont Bldg., Boston, Mass.	Oct. 2, 1907
Morse, Robert Brooks. Asst. San. Engr., Metropolitan Sewerage Comm., 17 Battery Pl., New York City	June 30, 1910
Morssen, Charles Michael. 747 St. Catherine St., West, Room 24, Montreal, Que., Canada	June 5, 1907
Morton, Leon Lincoln. Asst. Engr., Kansas City South. Ry., Texarkana, Tex.	Oct. 31, 1911
Mosley, Earl Louis. With Mackenzie, Mann & Co., Ltd., Care, Canadian North. Ry., Eng. Dept., Union Station, Winnipeg, Man., Canada	Sept. 6, 1910
Moss, Castle Prentice. Res. Engr. for Waddell & Harrington, Vancouver, B. C., Canada	June 3, 1903
Moss, Robert Edward. Structural Engr., 126 Liberty St., New York City.	May 2, 1900
Moss, Robert Faulkner. Care, Am. Trading Co., Yokohama, Japan. (*Jun., Nov. 1, 1904*)	Mar. 2, 1909
Mott, William Elton. Prof. of Civ. Eng., Carnegie Technical Schools, Pittsburgh, Pa.	Mar. 5, 1902
Mould, George Alexander Hutchings. 540 Fourth St., Brooklyn, N. Y.	Dec. 7, 1904

	Date of Membership
Muller, Leslie. Rd. Engr., Hudson & Manhattan Ry., 137 Christopher St., New York City	Feb. 1, 1910
Mundt, William Clyde. Engr., Oklahoma Div., The Texas Co., Tulsa, Okla	June 6, 1911
Munn, Alexander Majors. Director and Secy., Callahan Bros., Munn & Reise, Falls City, Nebr	Jan. 3, 1906
Munroe, Hersey. Topographer, U. S. Geological Survey, Washington, D. C.	Mar. 5, 1902
Munson, John Gephart. Parksville, Tenn	Sept. 6, 1910
Murphy, James Leo. 165 Broadway, New York City	April 4, 1911
Murphy, John Joseph. Asst. Engr., Dept. of Public Works, Borough of Manhattan, New York City (Res., 70 Park Hill Ave., Yonkers, N. Y.).	Mar. 2, 1909
Murphy, Joseph Edgar. Editorial Dept., *Constr. News,* 842 Monadnock Blk., Chicago, Ill	Sept. 2, 1903
Murphy, Robert Lincoln. Treas., Murphy Constr. Co., Murphy Bldg., East St. Louis, Ill	Nov. 7, 1906
Murray, Charles Warren. P. O. Box 576, Atlanta, Ga	Dec. 2, 1903
Murray, John Bonaventure. Engr., Fuller Eng. Co., 50 Church St., New York City	Sept. 6, 1910
Murray, Ray. 1024 Witherspoon Bldg., Philadelphia, Pa. (*Jun., Oct. 6, 1903*)	Dec. 4, 1907
Murray, Samuel. Bridge Engr., Ore.-Wash. R. R. & Nav. Co., Oregon-Washington Station, Seattle, Wash	Jan. 8, 1908
Musson, Charles Augustin Woodley. Asst. Engr., C., M. & P. S. Ry., 516 State Savings Bank Bldg., Butte, Mont	Sept. 5, 1911
Myers, Chester John. Asst. Engr., State Highway Comm., 6 Charles St., Cortland, N. Y. (*Jun., Oct. 1, 1901*)	Jan. 4, 1905
Myers, Edward Warren. Civ. and Hydr. Engr., 346 Arcade Bldg., Greensboro, N. C.	Oct. 2, 1901
Myers, John Hays. Engr., Second Div., New York State Public Service Comm., First Dist., 70 East 45th St., New York City. (*Jun., Dec. 5, 1893*)	Oct. 5, 1898
Myers, John Henry. B. and C. Dept., Penna. Steel Co., Steelton, Pa.	June 1, 1909
Myers, William Madison. With Virginia State Highway Comm., Winchester, Va	Oct. 3, 1906
Nagel, John. Supt., Manhattan Beach Estates, Manhattan Beach, N. Y.	June 30, 1910
Nash, Frank Dana. Clinton, La	May 4, 1909
Navarrete, Salvador Maria. Avenida Morelos 25, City of Mexico, Mexico.	Mar. 1, 1910
Neely, John Thompson. Engr., Care, McClintic-Marshall Constr. Co., Gatun, Canal Zone, Panama	Dec. 6, 1910
Neff, Frank Howard. Prof. of Civ. Eng., Case School of Applied Science; Address, 2087 East 105th St., Cleveland, Ohio	May 6, 1903
Nelson, Alexander Howard. Atlantic City, N. J. (*Jun., Nov. 1, 1898*).	April 5, 1905
Nelson, Arthur Thomas. Seattle Branch Mgr., Trussed Concrete Steel Co., 716 White Bldg., Seattle, Wash. (Res., 71 Esmond St., Dorchester, Mass.)	Jan. 8, 1908
Nelson, Clarence Lotario. Care, Bailey Willis, Poste Restante, Buenos Aires, Argentine Republic	Oct. 3, 1906
Nelson, Elbert James. 44 West Fountain Ave., Delaware, Ohio	Dec. 5, 1911
Nelson, Fred Burgess. Asst. Engr., Dept. of Water Supply, 966 Anderson Ave., Highbridge, New York City	April 6, 1909
Nelson, Oscar Benjamin. 942 Seventeenth Ave., S. E., Minneapolis, Minn.	Oct. 3, 1911
Nelson, William. Vice-Pres. and Sales Mgr., Osgood Scale Co., Binghamton, N. Y.	June 6, 1900
Neumeyer, Robert Engler. Borough Engr. of the Towns of Bethlehem and South Bethlehem; Chf. Engr., Minsi Trail Bridge Co., 501 Market St., Bethlehem, Pa. (*Jun., May 31, 1892*)	Mar. 3, 1897
Neville, Colone Will Jackson. Engr. and Contr. (Neville & Swiler), 1020 Maison Blanche Bldg., New Orleans, La. (*Jun., Oct. 1, 1901*)	June 3, 1903
Newbegin, Parker Cleaveland. Maintenance Engr., B. & A. R. R., Houlton, Me	May 1, 1907
Newberry, Spencer Baird. Vice-Pres. and Mgr., Sandusky Portland Cement Co., Bayridge, Ohio	Jan. 6, 1897
Newcomb, William Taft. Engr., Amies Road Co., 580 Bourse Bldg., Philadelphia, Pa	Feb. 6, 1912
Newell, Herbert Damon. Engr., U. S. Reclamation Service, Hermiston, Ore	Dec. 7, 1904
Newell, Robert J. 201 Mode Bldg., Boise, Idaho	Feb. 1, 1910
Newhall, Henry Lester. Care, Board of Water Supply of New York City, New Paltz, N. Y.	Feb. 28, 1911
Newhall, William Barrett. Mgr., The Southern Fruit Lands Irrigating Co.; Cons. Engr., Raymondville, Tex	Oct. 7, 1908
Newman, Arthur Traver. With A. L. Webster, 82 Wall St., New York City	Nov. 8, 1909

	Date of Membership
Newton, John Parsons. Asst. Engr., Dept. of State Engr. and Surv., Barge Canal Office, Albany, N. Y.	May 3, 1910
Newton, Samuel Donald. Asst. Engr., Southern Ry., Box 153, Greensboro, N. C.	June 1, 1909
Nial, William Augustine. With Nial Bros. Constr. Co., Troy, N. Y.	July 9, 1906
Nichol, Henry Schell. Structural Engr., Canadian Collieries (Dunsmuir), Ltd., Victoria, B. C., Canada. (*Jun., Jan. 2, 1906*)	June 6, 1911
Nichols, Henry Francis. Gen. Mgr. and Engr., James Hill & Sons, 63 Grenfell St., Adelaide, South Australia	Oct. 1, 1902
Nicol, Walter Hilliard. Acting Asst. Prof. of Civ. Eng., Tulane Univ., St. Charles Ave., New Orleans, La.	June 30, 1910
Nicolaysen, Albin Georg. Asst. Engr., State Board of Assessors, 125 West State St., Trenton (Res., 720 Leland Ave., Plainfield), N. J. (*Jun., Dec. 1, 1908*)	Oct. 4, 1910
Nikolitch, Milan. Asst. Chf. Engr., Chou River Irrig. Project, Ligovka 44 K. 627, Petersburg, Russia. (*Jun., Sept. 1, 1908*)	April 5, 1910
Nimmo, James Valence. Div. Engr., C. N. P. Ry., Lytton, B. C., Canada	Sept. 5, 1906
Nishkian, Leon Hagop. Hotel Columbia, San Francisco, Cal.	Oct. 3, 1911
Nixon, Courtland. Depot Quartermaster, Isthmian Canal Comm., Cristobal, Canal Zone, Panama	Nov. 1, 1905
Noble, Clarence Warren. Contr. Fire-Proofing Engr., 117 Home Life Bldg., Toronto, Ont., Canada	Feb. 3, 1904
Noble, Guy Lynn. Div. Engr., Dept. of State Engr. and Surv., 315 Rosenbloom Blk., Syracuse, N. Y.	Feb. 6, 1912
Noble, Walter Edwin. Asst. Engr., City Engr.'s Dept., City Hall, Fall River, Mass.	April 2, 1902
Noerr, Robert Collyer. Cons. Engr. (Greenwood & Noerr), 847 Main St. (Res., 120 Huntington St.), Hartford, Conn.	Jan. 2, 1907
Nolan, Simon Frank. Engr. in Bridge and Harbor Dept. of City Engr.'s Office (Res., 103 Bernon St.), Providence, R. I.	April 5, 1910
Nolen, William Isaac. Structural and Highway Bridge Engr., Copperhill, Tenn.	May 3, 1910
Norcross, Paul Howes. 1622 Candler Bldg., Atlanta, Ga.	July 9, 1906
Norcross, Theodore White. Dist. Engr., Forest Service, Majestic Bldg., Denver, Colo.	Nov. 8, 1909
Norris, Walter Henry. Bridge Engr., Maine Cent. R. R., 238 St. John St., Portland, Me.	Sept. 6, 1905
North, Arthur Tappan. 1218 Monadnock Bldg., Chicago, Ill.	Feb. 7, 1906
Northrop, Albert Allen. Auditing Engr., Mississippi River Power Co., Keokuk, Iowa	July 9, 1906
Noyes, Harry Lincoln. Mech. Engr., Union Carbide Co., Niagara Falls, N. Y.	June 5, 1901
Noyes, Stephen Henley. Care, Pennsylvania Steel Co., Steelton, Pa. (*Jun., Oct. 1, 1907*)	Feb. 6, 1912
Nye, Algernon Sidney. 351 West 51st St., New York City. (*Jun., July 2, 1890*)	April 5, 1905
Oakes, Luther Stevens. Care, Winston Bros. Co., 801 Globe Bldg., Minneapolis, Minn.	Jan. 4, 1905
Oakley, George Israel. Asst. Engr., Contract No. 30, New York State Barge Canal, Herkimer, N. Y. (*Jun., Oct. 6, 1903*)	Nov. 6, 1907
Obreiter, Joseph William. 213 Seventh St., Hoboken, N. J.	Nov. 6, 1907
O'Brien, Daniel Bernard. Civ. Engr. and Contr., 1722 Park St., Syracuse, N. Y. (*Jun., April 3, 1906*)	May 3, 1910
O'Brien, William Arthur. Chf. Engr., Little River Drainage Dist., 304 Himmelberger-Harrison Bldg., Cape Girardeau, Mo.	Jan. 2, 1912
O'Connell, George Paul. Asst. Engr., Board of Water Supply, New York City, Brown Station, N. Y.	Sept. 6, 1910
O'Connor, Cornelius Joseph. 770 East 179th St., New York City. (*Jun., Mar. 1, 1904*)	June 5, 1907
O'Connor, John Adam. Engr. of Terminals, State of New York, 131 Lancaster St., Albany, N. Y.	April 1, 1908
Odoni, Vincent Phillip. P. O. Box 187, Tucson, Ariz.	April 4, 1911
O'Hara, Francis Joseph. Asst. Engr., S. P. R. R., 1111 Flood Bldg., San Francisco, Cal.	June 6, 1911
O'Hara, Joseph Matthew. Engr. in Chg. of S. P. Co. Testing Laboratory, 1109 Flood Bldg., San Francisco, Cal.	June 30, 1910
O'Hearn, John Lynch. Cons. Engr., Clinton, Okla. (*Jun., Feb. 5, 1907*)	Nov. 4, 1908
Oinouye, Chikao. Care, Koto-Kogio-Gakko, Sendai, Japan	Feb. 7. 1906
Olberg, Charles Real. Supt., Irrig., Indian Service, 522 Bumiller Bldg., Los Angeles, Cal.	May 7, 1902
Older, Clifford. Bridge Engr., Ill. Highway Comm., Springfield, Ill.	Oct. 4, 1905
Olds, Clark. Erie, Pa.	Mar. 1, 1899
Omberg, James Adolphus, Jr. Cons. Engr., 526 Goodwyn Inst. Bldg., Memphis, Tenn.	April 1, 1903

	Date of Membership
O'NEIL, JOSEPH. Pres., O'Neil Constr. Co., Leavenworth, Kans	Feb. 1, 1910
OPDYCKE, HENRY GORTON. 30 Church St., New York City	Sept. 7, 1904
ORR, ALEXANDER. Supt., Water-Works, Gloversville, N. Y. *(Jun., June 4, 1901)*	Feb. 5, 1902
ORRELL, JAMES ATHERSMITH. 7 Wakefield Rd., Bradford, England	Dec. 5, 1911
ORTIZ, EDUARDO. 2ª Pánuco 41, City of Mexico, Mexico. *(Jun., Nov. 4, 1902)*	May 1, 1907
OSBORN, OLLIE STEELE. Asst. Engr., Ore. Short Line R. R., Vale, Ore	Oct. 2, 1901
OSBORNE, GEORGE FREDERICK FOLGER. Box 84, Gen. Post Office, Toronto, Ont., Canada	Dec. 7, 1904
OSBOURN, HENRY VAN BUREN. Party Chf., Corps No. 1, Seventh Dist., Pennsylvania State Highway Dept., 610 Mutual Life Bldg., Philadelphia, Pa	Sept. 3, 1902
OTT, SAMUEL JACOB. Elm Ave., Hackensack, N. J	Feb. 6, 1907
OWEN, ARTHUR EDMUND. Prin. Asst. Engr., C. R. R. of N. J., 81 Grove St., Montclair, N. J	May 3, 1905
OWEN, ELIJAH HUNTER. Engr., Larrowe Constr. Co., 1199 Woodward Ave., Detroit, Mich	June 6, 1906
OWENS, HAROLD VAN DYKE. Secy. and Treas., Dale Eng. Co., Utica, N. Y	Oct. 3, 1911
OWENS, JAMES MICHAEL. Asst. Engr. in Chg., Dept. of Street Impvts., Office of City Engr., Board of Public Works, San Francisco, Cal. *(Jun., April 4, 1905)*	Jan. 8, 1908

PACE, FULTON. Engr. for Central Aguirre, Central Aguirre, Porto Rico. *(Jun., Nov. 5, 1907)*	Feb. 2, 1909
PACKARD, DANIEL BERRY. City Engr., Washington, N. C	June 6, 1911
PADDOCK, HOWARD CHARLES. Designing Engr., The Turner Constr. Co., 11 Broadway, New York City	June 1, 1909
PAGET, CHARLES SOUDERS. Archt. and Engr. (Purnell & Paget), Canton, China	Nov. 1, 1910
PAIGE, JASON. Contr. Engr., Pittsburgh Steel Products Co., 38 South Dearborn St., Chicago, Ill. *(Jun., Feb. 5, 1907)*	Feb. 2, 1909
PAINE, HIBBARD ATWILL. Road Engr., Caroline County, Denton, Md	Feb. 4, 1903
PALM, THOMAS JEFFERSON. U. S. Junior Engr., Box 1092, Dallas, Tex	Oct. 4, 1910
PALMER, GEORGE BRUCE. Engr., Right-of-Way, Penn. Lines W. of Pitts., 1106 Union Station, Pittsburgh, Pa	April 6, 1909
PALMER, MARSHALL BARKER. Asst. Engr., Syracuse Water Supply, City Hall (Res., 104 Amherst Ave.), Syracuse, N. Y	June 5, 1907
PAQUETTE, CHARLES ALFRED. Asst. Chf. Engr., C., C., C. & St. L. Ry., Cincinnati, Ohio	April 6, 1898
PARK, CHARLES ABRAHAM. Lighthouse Supt., 11th Lighthouse Dist., Detroit, Mich	Oct. 31, 1911
PARK, JAMES CALDWELL. 20 South Ave., Cranford, N. J. *(Jun., Feb. 28, 1905)*	June 3, 1908
PARKER, CHARLES FREDERICK. Apartado 208, Durango, Dgo., Mexico. *(Jun., June 5, 1900)*	Sept. 2, 1903
PARKER, GLENN LANE. Asst. Engr., U. S. Geological Survey, 208 Tilford Bldg., Portland, Ore	June 30, 1911
PARKER, JAMES LAFAYETTE. Prin. Asst. Engr. to Herbert C. Keith, 116 Nassau St., Room 901, New York City. *(Jun. April 2, 1907)*	May 3, 1910
PARKER, JOHN CASTLEREAGH. Mech. and Elec. Engr., Rochester Ry. & Light Co., Rochester, N. Y. *(Jun., Dec. 6, 1904)*	May 6, 1908
PARKER, PHILIP A MORLEY. Care, Capt. Parker, R. N., Philipsfield House, St. Michaels, Ashford, Kent, England	Mar. 6, 1907
PARKER, RICHARD DENNY. Engr., R. R. Comm. of Texas, Austin, Tex. *(Jun., June 3, 1902)*	Mar. 7, 1906
PARSONS, ARCHIBALD LIVINGSTONE. Civ. Engr., U. S. N., Public Works Office, Navy Yard, Brooklyn, N. Y	May 7, 1902
PARSONS, AUGUSTUS TABER. Civ. Engr. and Surv. (Parsons & Barton), Box 435, Bakersfield, Cal. *(Jun., June 5, 1906)*	Oct. 4, 1910
PARSONS, CHARLES EDWARD. 88 Pearl St., Boston, Mass	May 6, 1903
PARTHESIUS, PHILIP HENRY. Senior Eng. Examiner with New York State Civil Service Comm, 152 Third St., Troy, N. Y	Nov. 1, 1910
PATERSON, CHARLES JUDSON. Care, The Republic Structural Iron Works Co., Cleveland, Ohio. *(Jun., Feb. 1, 1910)*	Oct. 31, 1911
PATTERSON, CLAIR BRANDON. Res. Engr., A., C. & Y. Ry., R. F. D. No. 20, Box 111, East Akron, Ohio	July 1, 1909
PATTERSON, ROBERT YOUNGMAN. 1365 Meridian Pl., N. W., Washington, D. C	Jan. 8, 1908
PAWLING, GEORGE FRANKLIN. Gen. Mgr., Bergdoll & Pawling, Engrs. and Contrs., Broad and Vine Sts., Philadelphia (Res., Ridley Park), Pa	April 4, 1906
PAYNE, JAMES HENRY. 543 Pacific Elec. Bldg., Los Angeles, Cal	Feb. 5, 1908
PEABODY, LIONEL HENRY. Associate with O. Perry Sarle, 146 Westminster St., Providence, R. I. *(Jun., Feb. 6, 1906)*	Jan. 4, 1910

	Date of Membership
Pearse, Langdon. Asst. Engr. in Chg., Sewage Disposal Investigations, The San. Dist. of Chicago, 39th St. Sewage Pumping Station, 39th St. and the Lake Front, Chicago, Ill. *(Jun., Jan. 6, 1903)*	Oct. 7, 1908
Pearse, William Worth. First Vice-Pres. and Engr., Radley Steel Constr. Co., 624 East 19th St., New York City	Sept. 5, 1911
Pease, Frederick Atwood. Gen. Mgr., The F. A. Pease Eng. Co., Williamson Bldg., Cleveland, Ohio	June 5, 1907
Peck, Ermon Miland. Engr. in Chg., Mech. Dept., Water-Works of Hartford, 260 Edgwood St., Hartford, Conn	April 5, 1910
Peck, Myron Hall. Engr., Standard Am. Dredging Co., 6426 Duncan St., Oakland, Cal	Jan. 5, 1909
Peden, Leo Thomas. Special Engr., Eng. Dept., City of Dallas; Res., 1813 Crockett St., Dallas, Tex	May 31, 1910
Pellissier, George Edward. Supt. and Chf. Engr., Goldschmidt Thermit Co., 90 West St., New York City. *(Jun., Feb. 28, 1905)*	July 1, 1909
Pendlebury, Edward. Asst. Engr., Public Service Comm., 154 Nassau St., New York City. *(Jun., Oct. 2, 1906)*	April 5, 1910
Pendleton, David Elliott. Engr. in M. of W. Dept., H. & Tex. Cent. R. R., Ennis, Tex. *(Jun., Jan. 2, 1906)*	Oct. 31, 1911
Pense, Edward Herbert. Box 560, Ottawa, Ont., Canada	Feb. 28, 1911
Peotter, Reuben Sylvester. Res. Engr., Knoxville Power Co., Chilhowee, Tenn	Nov. 30, 1909
Perkins, Philo Sackett. Asst. Engr., N. Y., N. H. & H. R. R., 59 Chester Ave., Providence, R. I. *(Jun., Mar. 5, 1890)*	April 3, 1895
Perley, Alan Bigelow. Cons. Engr., 46 Gowen St., Mt. Airy, Philadelphia, Pa	June 1, 1909
Perring, Henry Garfield. 144 West 8th St., Jacksonville, Fla	Nov. 6, 1907
Perrot, Emile George. Archt. and Engr. (Ballinger & Perrot), 1211 Arch St., Philadelphia, Pa	Feb. 6, 1907
Perry, Charles Edwards. (Vrooman & Perry), Canajoharie, N. Y	Sept. 5, 1911
Perry, Francis William. Engr. of Constr., Dept. of Bridges, New York City (Res., 214 Parkside Ave., Brooklyn, N. Y.)	Jan. 5, 1909
Peters, Frederic Hatheway. Commr. of Irrig., Canada, P. O. Drawer V, Calgary, Alta., Canada	June 30, 1910
Peters, John Marvin. Inspecting Engr., P. & L. E. R. R., McKeesport, Pa. *(Jun., May 1, 1906)*	Nov. 1, 1910
Petersen, Charles Walter. Engr. of Track Elevation, Rock Island Lines, 802 La Salle St. Station, Chicago, Ill	Feb. 6, 1907
Peterson, Otto Wallace. Div. Engr., Los Angeles Aqueduct, Lone Pine Cal	Oct. 31, 1911
Petheram, George Thomas. Chf. Engr., Hanford Irrig. & Power Co., Hanford, Benton Co., Wash	Feb. 28, 1911
Pettebone, Lauren Augustus. 307 Buffalo Ave., Niagara Falls, N. Y	Feb. 2, 1909
Pfeifer, Herman Julius. Engr., M. of W., Terminal R. R. Assoc. of St. Louis, St. Louis Merchants Bridge Terminal Ry., 2145 Blendon Pl., St. Louis, Mo	Sept. 6, 1899
Pfeiffer, George Whitfield. Gen. Supt., Spanish-American Iron Co., Santiago de Cuba, Cuba	Oct. 5, 1904
Pflueger, Alvin Cyrus. 2637 Germantown Ave., Philadelphia, Pa	June 5, 1907
Philbrook, Lee Elmo. With E. C. & R. M. Shankland, 5427 Jefferson Ave., Chicago, Ill	May 3, 1910
Phillips, Howard Crathorne. Chf. Engr., A., T. & S. F. Ry. Coast Lines, Los Angeles, Cal. *(Jun., April 5, 1892)*	Sept. 6, 1899
Phillips, John Carleton. U. S. Junior Engr., Fort Flagler, Wash	Jan. 3, 1911
Phillips, Silas Bent. Engr. in Chg. of Design of Structures, Ore. & Wash. R. R., 306 Oregon-Washington Station, Seattle, Wash	Aug. 31, 1909
Phillips, Theodore Clifford. Civ. and Hydr. Engr., 5009 Washington Ave., Chicago, Ill	Mar. 2, 1904
Phillips, William Hale. 733 Peyton Bldg., Spokane, Wash. *(Jun., Nov. 1, 1904)*	May 4, 1909
Phinney, Cassius Morton. (Phinney, Cate & Marshall), 434 Forum Bldg., Sacramento, Cal	Sept. 5, 1911
Phipps, Thomas Elmer. Locating Engr., 834 Fifteenth Ave., Seattle, Wash	Oct. 3, 1911
Pickwick, Edwin Job. Engr. and Contr., Holland Patent, N. Y	Jan. 5, 1909
Pierce, George Abel. Draftsman, Mo. Pac. Ry., Room 801, Mo. Pac. Bldg., St. Louis, Mo	Jan. 5, 1909
Pierce, James Wilson. Durham, N. C	Feb. 3, 1904
Pierce, Paul Leon. Constr. Mgr., North State Hydro-Elec. Co., Raleigh, N. C. *(Jun., Jan. 7, 1908)*	Oct. 3, 1911
Pierce, Thomas Day. Res. Engr., Erie R. R., Cambridge Springs, Pa	Sept. 5, 1911
Pike, Ralph Ashur. Constr. Dept., Mex. N. W. Ry., 710 N. Campbell St., El Paso, Tex. *(Jun., Mar. 6, 1906)*	Jan. 31, 1911
Pill, John Richards. Gen. Supt., Galloway Coal Co.; Vice-Pres. and Gen. Mgr., Choctaw Coal & Min. Co., 1111 Twelfth Ave., South, Birmingham, Ala	Feb. 7, 1906

	Date of Membership
Pillsbury, George Bigelow. Capt., Corps of Engrs., U. S. A., West Point, N. Y.	Dec. 7, 1904
Pires do Rio, José. 93 rua Quitanda, Rio de Janeiro, Brazil	Jan. 4, 1910
Pistor, George Emil John. Contr. Engr., Hay Foundry & Iron Works, 114 East 28th St., New York City. (*Jun., Dec. 3, 1901*)	July 10, 1907
Pitkethly, David Thomas. Asst. Engr., Bureau of Sewers, Borough of Brooklyn, Atlantic St., Jamaica, N. Y.	April 6, 1909
Plock, Albert Francis. 3506 Fifth Avenue, Pittsburgh, Pa.	Nov. 8, 1909
Plogsted, Walter John. Res. Engr. and Supt. of Constr., Gen. Ry. Signal Co., 55 Liberty St., Suite 2806, New York City. (*Jun., Oct. 6, 1903*)	May 4, 1909
Plummer, Horace Edwards. 497 East 27th St., Portland, Ore. (*Jun., April 30, 1907*)	Feb. 1, 1910
Podewils, Otto Charles Julius. Chf. Estimator, George A. Just Co., 239 Vernon Ave., Long Island City, N. Y.	Jan. 3, 1911
Poe, Harry Tinker, Jr. Traveling Engr., The Buckeye Cotton Oil Co., 1008 Empire Bldg., Atlanta, Ga.	Feb. 5, 1908
Poe, Joseph Ralph. Civ. and Structural Engr., 1458 Lakewood Ave., Lakewood, Ohio	Feb. 5, 1908
Pohl, Charles Andrew. Care, John Bogart, 141 Broadway, New York City.	Oct. 2, 1907
Polk, Armour Cantrell. Supt. of Constr., Springfield Gas & Elec. Co. and Springfield Traction Co., Box 211, Springfield, Mo. (*Jun., Oct. 6, 1903*)	May 2, 1906
Polk, Martin Collins. City Engr., Chico, Cal.	Nov. 1, 1910
Pollock, George Gordon. Engr. and Asst. Mgr., Ross Const. Co., Box 727, Sacramento, Cal.	Jan. 2, 1912
Pond, Harry Bradford. 2ª Calle de Barcelona No. 24, City of Mexico, Mexico	May 4, 1909
Poole, Charles Arthur. Gen. Asst., Sewage Disposal, City Engr.'s Office, Rochester, N. Y.	June 5, 1907
Poole, John Hudson. Cons. Engr., 1216 Ford Bldg., Detroit, Mich.	June 1, 1909
Popert, William Hopf. Contr. Engr., United States Steel Products Co., Bridge and Structural Dept., Room 609, Rialto Bldg., San Francisco, Cal.	Nov. 4, 1908
Porter, James Madison. Prof., Civ. Eng., Lafayette Coll., Easton, Pa.	May 4, 1892
Porter, John Endicott. Asst. Engr., Office of Engr. of Structures, N. Y. C. & H. R. R. R., 7th Floor, Grand Central Palace, New York City (Res., 6 Ashburton Pl., Yonkers, N. Y.). (*Jun., Sept. 1, 1903*)	May 2, 1911
Post, Chester Leroy. Cons. Engr., Associated with T. L. Condron, 1214 Monadnock Bldg., Chicago, Ill.	July 1, 1908
Post, William Schuyler. Engr., Volcan Land & Water Co., Rampart Apartments, Los Angeles, Cal.	May 1, 1901
Potter, Alexander. Cons. Engr., 114 Liberty St., New York City. (*Jun., Jan. 4, 1888*)	Jan. 6, 1892
Potter, James Rowland. Contr., 400 Coleman Bldg., Philadelphia, Pa.	June 6, 1906
Powell, Maurice Vernon. Care, Madeira-Mamoré Ry., Caixa 304, Manãos, Brazil	Oct. 4, 1910
Powell, Thomas Jett. Surface Div., Engr. Dept., Dist. of Columbia (Res., 212 Thirteenth St., N. E.), Washington, D. C.	Mar. 2, 1909
Pratt, Arthur Henry. Senior Section Engr., White Plains Div., New York City Board of Water Supply; Res., 24 Summit Ave., White Plains, N. Y.	July 1, 1908
Pratt, Henry Blanchard. Asst. Engr., J. R. Worcester & Co.; Res., 750 Lexington St., Waltham, Mass.	June 1, 1909
Pratt, Joel Marsh. U. S. Asst. Engr., U. S. Engr.'s Office (Res., 24 South Catherine St.), Mobile, Ala.	July 1, 1909
Prentice, William Hendry, Jr. Supt., Morey-Faulhaber Constr. Co., Chemical Bldg., St. Louis, Mo.	April 4, 1906
Pressey, Henry Albert. Hibbs Bldg., Washington, D. C.	May 1, 1901
Preston, George Henry. Structural Engr., F. T. Ellithorpe & Co., 17 Battery Pl., New York City (Res., 43 Orchard St., Bloomfield, N. J.)	April 4, 1911
Preston, Harry Longyear. Res. Engr., N. Y. C. & H. R. R. R., Jordan, N. Y.	April 1, 1908
Price, Frank Oliver. Instr. in Materials and Constr., Pratt Inst., 101 Quincy St., Brooklyn, N. Y.	May 2, 1911
Price, Paul Leon. Chf. Engr., Irving Iron Works Co., Long Island City, N. Y.	Oct. 3, 1906
Price, Philip Wallis. County Engr.'s Office, Court House, Pittsburgh, Pa. (*Jun., April 2, 1901*)	Feb. 5, 1908
Priest, Benson Bulkeley. Care, Am. Bridge Co., 30 Church St., New York City	April 4, 1906
Prime, Alfred Coxe. Engr., P. R. R., 1008 Spruce St., Philadelphia, Pa.	Nov. 4, 1908
Prince, Arthur Dickson. Senior Asst. Div. Engr., Public Service Comm., First Dist., 154 Nassau St. (Res., 274 West 94th St.), New York City. (*Jun., May 5, 1896*)	Oct. 3, 1900
Pritchard, Clifford Moses. Contr. Engr., Kansas City Structural Steel Co., 808 Herskowitz Bldg., Oklahoma, Okla.	April 1, 1903

	Date of Membership
Pritchard, John Charles. Asst. Engr., Water Dept., 4245 Evans Ave., St. Louis, Mo. *(Jun., Sept. 1, 1908)*	Oct. 4, 1910
Pritchard, Philip Morris. Chf. Engr., United Alkali Co., Ltd., Widnes, Lancashire, England	June 6, 1900
Proctor, Lewis Jefferson. Gen. Agt., New Trinidad Lake Asphalt, Trinidad Lake Petroleum Co., and New York & Bermudez Co., Port of Spain, Trinidad	Mar. 1, 1905
Proctor, Ralph Fenno. Engr. and Gen. Mgr., A. L. Register & Co., 112 North Broad St., Philadelphia, Pa. *(Jun., June 3, 1902)*	Oct. 4, 1905
Prouty, Edward Nathan. Asst. Engr., M. of W. Dept., N. W. Pac. Ry., San Rafael, Cal	Feb. 3, 1904
Pullar, William Murray. St. Kitts, Essendon, Victoria, Australia	Aug. 31, 1909
Purver, George Moses. Cons. Engr., 146 East 8th St., Brooklyn, N. Y	Oct. 3, 1911
Quimby, John Herman. 11 North 18th St., East Orange, N. J	April 5, 1910
Quinby, Charles Edward. Chf. Engr. and Supt. of Constr., Ludlow Mfg. Co., Ludlow, Mass	Sept. 6, 1905
Quirk, James Francis. Asst. Engr., New York Board of Water Supply, Brown Station, N. Y	Jan. 3, 1911
Race, John Marble. Housatonic, Mass	Mar. 5, 1902
Raider, Harry Adam. Care, Bureau of Public Works, Manila, Philippine Islands	Nov. 1, 1910
Rainbow, John Roworth. Archt., 3 East 33d St., New York City	Jan. 6, 1904
Raleigh, Wilbur Collins. City Engr., Tacoma, Wash	Feb. 28, 1911
Ramey, Horace Patton. Asst. Engr., San. Dist. of Chicago, 76 West Monroe St., Room 1500, Chicago, Ill	Oct. 3, 1911
Ramsbotham, Joshua Fielden. Box 81, Fremantle, Western Australia	Oct. 31, 1911
Ramsey, Guy Robert. City Engr., Orlando, Fla	Oct. 7, 1903
Randall, Frank Alfred. Chf. Engr., Morey, Newgard & Co., 21 East Van Buren St., Chicago, Ill	Dec. 5, 1911
Randolph, John Hampden, Jr. Care, Guild & Co., James Bldg., Chattanooga, Tenn	Dec. 5, 1906
Randolph, Orrin. Chf. Engr., Palm Beach Farms Co., Box 1123, West Palm Beach, Fla	Oct. 3, 1911
Randolph, Richard Wood. Asst. Engr., Bureau of Public Works, Manila, Philippine Islands	Dec. 6, 1910
Randolph, Robert Isham. Secy., Rivers and Lakes Comm. of Illinois, 826 First National Bank Bldg., Chicago, Ill. *(Jun., July 1, 1909)*	Nov. 1, 1910
Randorf, Charles Andrew. Structural Engr., Lackawanna Steel Co., Buffalo, N. Y	Dec. 6, 1910
Rankin, Harry Howard. Civ. and Min. Engr., 331 Fourth Ave., Pittsburgh (Res., 5547 Raleigh St., Squirrel Hill), Pa	Mar. 1, 1905
Rannells, Clarence J. Little Hocking, Ohio	Oct. 3, 1906
Ranney, Charles Garfield. Asst. Engr., Contract No. 30, N. Y. State Barge Canal, Mohawk, N. Y. *(Jun., April 30, 1907)*	Feb. 1, 1910
Ranson, Birtram Willard. 417 Plymouth Bldg., Minneapolis, Minn. *(Jun., Sept. 3, 1907)*	Oct. 5, 1909
Rapalje, Herbert deWitt. Pres., Southern Map Co.; Cons. Civ. and Elec. Engr., 511 Southern Bldg., Wilmington, N. C	Sept. 6, 1910
Ravenscroft, Edward Hawks. 4757 E. Ravenswood Pk., Chicago (Res., Glencoe), Ill	Nov. 6, 1907
Raynor, Clarence Webster. Chf. Engr., Coast Bridge Co., Suite 407, Ry. Exchange, Portland, Ore. *(Jun., Feb. 4, 1902)*	April 6, 1904
Reed, Alfred Clare. Supt., The Spanish-American Iron Co., Felton, Oriente, Cuba	June 5, 1907
Reed, William Belden, Jr. Vice-Pres. and Treas., The White Plains Constr. Co., 133 Railroad Ave., White Plains, N. Y. *(Jun., Dec. 1, 1896)*	June 5, 1907
Reed, William Thomas. Pres. and Treas., New England Concrete Constr. Co., 201 Devonshire St., Boston, Mass	Feb. 28, 1911
Reedy, Oliver Thomas. Engr., U. S. Reclamation Service, Scottsbluff, Nebr.	June 6, 1906
Reel, Charles Gordon. State Supt. of Highways, Albany (Res., Kingston), N. Y	June 5, 1907
Reeves, Carl Howell. Bridge and Field Engr., Stone & Webster Eng. Corporation, 4722 Latona Ave., Seattle, Wash. *(Jun., May 2, 1905)*	July 1, 1909
Reichardt, Walter Frederick. Cons. Engr., 102 Louisiana St., Little Rock, Ark. *(Jun., Jan. 31, 1905)*	July 10, 1907
Reid, Homer Austin. Asst. Engr., Bureau of Bldgs., Borough of Manhattan (Res., 400 West 150th St.), New York City	Dec. 4, 1901
Reid, John Winfield. Bridge Engr., C. & A. R. R. and Tol., St. L. & West. R. R., 900 Railway Exchange Bldg., Chicago, Ill	Feb. 28, 1911
Reimer, Arthur Adams. Engr., Water Dept., City Hall, also 45 South Maple Ave., East Orange, N. J	Mar. 6, 1907

ASSOCIATE MEMBERS R

	Date of Membership
Reimer, Frederic Adams. 51 North Maple Ave., East Orange, N. J.	April 6, 1909
Reinhardt, Jacob Brunn. Res. Engr., N. Y. C. R. R., 110 Shepard St., Rochester, N. Y.	May 2, 1911
Remsen, Thomas Richard. 283 Jefferson Ave., Brooklyn, N. Y.	Jan. 31, 1911
Renshaw, Francis Orea. P. O. Box 539, Huntington, W. Va.	Jan. 3, 1911
Reynolds, Justin Oakley. Engr. of Elev. Lines, Brooklyn Rapid Transit System, 85 Clinton St., Brooklyn, N. Y. *(Jun., Oct. 6, 1896)*	Dec. 5, 1900
Reynolds, Lafayette Clowe. Res. Engr., Erie Works, Gen. Elec. Co. (Res., 541 West 9th St.), Erie, Pa. *(Jun., Feb. 6, 1906)*	Dec. 1, 1908
Rhett, Albert Haskell. Structural Engr., N. Y., Westchester & Boston Ry., Grand Central Terminal, New York City	Sept. 6, 1910
Rhoades, Theodore Eckford. Vice-Pres., The Whitney Co., 1 Liberty St., New York City	June 1, 1909
Rhodes, Claude Irvin. 336 Capp St., San Francisco, Cal. *(Jun., Mar. 5, 1907)*	Mar. 1, 1910
Rhodes, Fred Dana. Cons. Engr., 140 Cedar St., New York City. *(Jun., June 6, 1899)*	Nov. 6, 1901
Rice, Guy Wickliffe. Chf. Engr., Goose Lake Val. Irrig. Co., Lakeview, Ore.	May 3, 1910
Rice, Herbert Allan. Assoc. Prof., Civ. Eng., Univ. of Kansas, 1304 Ohio St., Lawrence, Kans.	June 7, 1905
Rice, John Marie Thomas. Asst. Engr., Bureau of Water (Res., 5307 Butler St.), Pittsburgh, Pa. *(Jun., April 2, 1907)*	Dec. 6, 1910
Rice, Ray Howard. Chf. Draftsman, Norfolk South. R. R., Norfolk, Va.	July 1, 1909
Rich, John Robert. Asst. Engr., N. & W. Ry., Bandy, Va.	Dec. 6, 1910
Rich, Melvin S. 1448 Harvard St., Washington, D. C. *(Jun., Sept. 5, 1905)*	May 31 1910
Richardson, Frederick Hosea. Box 297, Republic, Wash.	Sept. 5, 1911
Richardson, James Herbert. Care, Engr. of Structures, N. Y. C. & H. R. R. R., Boston, Mass.	Jan. 2, 1907
Richardson, Jeremiah Daniels. 60 Vine St., Corona, N. Y. *(Jun., Jan. 7, 1908)*	Sept. 5, 1911
Richardson, John Francis. Care, U. S. Reclamation Service, Hermiston, Ore. *(Jun., Oct. 3, 1899)*	June 5, 1907
Richardson, Rex Densmore. 1035 Woodlawn Ave., Scranton, Pa.	Aug. 31, 1909
Richmond, Jackson Litton. (Skene & Richmond), 606 Victoria Bldg., St. Louis, Mo.	Oct. 4, 1910
Richmond, Julian Pierre William. Asst. Engr., Board of Water Supply, 165 Broadway, New York City (Res., Dunwoodie Heights, Yonkers, N. Y.). *(Jun., Feb. 2, 1904)*	Dec. 4, 1907
Richmond, Waldemar Spaulding. Junior Engr., U. S. Lake Survey, Old Custom House, Detroit, Mich.	Oct. 3, 1911
Riedel, John Charles. Instr. of Mechanics, Cooper Union; Asst. Engr., Bureau of Sewers, 686 Halsey St., Brooklyn, N. Y.	Oct. 4, 1905
Riegel, Ross Milton. Asst. Engr., Designing Div., Board of Water Supply, 165 Broadway, New York City. *(Jun., Mar. 5, 1907)*	Feb. 28, 1911
Riegler, Louis John. Engr., Pennsylvania Co., Pittsburgh (Res., Church Ave., Ben Avon), Pa.	Sept. 3, 1902
Riggs, Charles Albert. Chf. Draftsman, J. A. Stewart and Cin. Union Depot & Terminal Co., 540 East 3d St., Newport, Ky.	June 6, 1911
Riggs, Thomas, Jr. Engr. to the Comm., Alaskan Boundary Survey, Coast and Geodetic Survey, Washington, D. C.	April 6, 1909
Rightmire, Estel Dean. Atlantic City, N. J.	Aug. 31, 1909
Rightor, Fred Elmer. Office Engr., Texas Bitulithic Co., Box 314, Austin, Tex.	May 31, 1910
Rights, Eugene Jesse. 3806 Manayunk Ave., Wissahickon, Philadelphia, Pa.	Mar. 2, 1909
Rights, Herbert Timothy. Asst. Engr., Lewis F. Shoemaker & Co., Harrison Bldg., Philadelphia, Pa.	April 5, 1910
Ripley, Blair. Asst. Engr., C. P. Ry., Montreal, Que., Canada	April 1, 1908
Rittenhouse, Harvey. Engr., M. of W., C. & P. R. R., Box 604, Cumberland, Md. *(Jun., April 4, 1893)*	Dec. 7, 1898
Ritter, Rollin. Engr., U. S. Indian Irrig. Service, Black Rock, N. Mex.	May 31, 1910
Roach, James Howard. Div. Engr., Cleveland Short Line Ry., Cleveland, Ohio	April 5, 1910
Roake, Stephen Allen. Asst. Engr., Am. Bridge Co., Trenton, N. J.	June 6, 1911
Robb, Louis Adams. 71 Lincoln Park, Newark, N. J. *(Jun., May 5, 1903)*	Oct. 5, 1904
Robbins, Dana Watkins. Secy. and Engr., Spuyten Duyvil Constr. Co., 271 West 125th St., Room 213, New York City	Oct. 3, 1906
Robbins, Franklin Henry. Asst. Designing Engr., New York Board of Water Supply, 165 Broadway, New York City	July 10, 1907
Robbins, Hallet Rice. Civ. and Min. Engr., P. O. Box 51, Seattle, Wash. *(Jun., Nov. 5, 1907)*	Nov. 8, 1909
Roberts, Harry Ashton. Asst. Supt., Montana Div., Ore. Short Line R. R., Pocatello, Idaho. *(Jun., April 5, 1904)*	Dec. 5, 1906

	Date of Membership
Roberts, William Williams, Jr. Supt., Turner Constr. Co., 11 Broadway, New York City	Jan. 31, 1911
Robertson, Avalon Graves. Engr. in Chg., Constr., Care, United Fruit Co., Bocas del Toro, Panama. (*Jun., Oct. 6, 1908*)	Jan. 3, 1911
Robinson, Arthur Pierce. Vice-Pres., Insley Mfg. Co.; Vice-Pres. and Chf. Engr., W. E. Austin Machinery Co., 2 Spring St., Atlanta, Ga.	Dec. 5, 1911
Robinson, Edward William. Vice-Pres., Ruggles-Robinson Co., 331 Madison Ave., New York City	Oct. 7, 1908
Robinson, Ernest Franklin. U. S. Engr. Office, Room 710, Army Bldg., New York City. (*Jun., Mar. 3, 1908*)	Oct. 4, 1910
Robinson, Frank Miner. Asst. Engr., W. P. Ry., 1930 Q St., Sacramento, Cal.	Jan. 2, 1907
Robinson, Harry Hayes. Asst. Engr., Maine Cent. R. R., Portland, Me.	May 4, 1904
Robinson, Herbert Fulwiler. Supt. of Irrig., U. S. Indian Service, 310 Federal Bldg., Albuquerque, N. Mex.	July 10, 1907
Robinson, Holton Duncan. 357 West 121st St., New York City. (*Jun., Mar. 1, 1893*)	Jan. 3, 1894
Robinson, Reuben Totman. C., H. & D. Ry., Dayton, Ohio	Mar. 4, 1908
Robson, Frederick Thurston. (Sloan & Robson), Nevada Bank Bldg., San Francisco, Cal.	June 6, 1911
Rockenbach, Samuel Dickerson. Capt., 12th Cavalry, U. S. A., Army War Coll., Washington, D. C.	Feb. 6, 1901
Rockwell, Edward Henry. Prof. of Structural Eng., Tufts Coll.; Cons. Engr., Tufts College, Mass.	June 1, 1909
Rockwood, Edward Farnum. Chf. Engr., New England Concrete Constr. Co., 201 Devonshire St., Boston, Mass.	Oct. 5, 1909
Rodenbough, James Foster. 203 West 54th St., New York City	April 3, 1907
Rogers, Augustus Webster. Standard Oil Co., Road Oil Dept., 6 Onondaga Pl., Syracuse, N. Y.	Nov. 1, 1910
Rogers, Herbert Lincoln. Archt., Board of Water Supply, 299 Broadway, New York City	May 3, 1905
Rojas, Pedro José. Maracaybo, Venezuela	Jan. 31, 1911
Roland, John Wilson. Prof., Civ. Eng., Nova Scotia Tech. Coll., 6 Mitchell St., Halifax, N. S., Canada	June 30, 1911
Rose, William Henry. Capt., Corps of Engrs., U. S. A., Gatun, Canal Zone, Panama	Oct. 3, 1911
Rosenberg, Friedrich. Engr., Charles L. Pitts Co., Contrs., 58 E. Park St., Newark, N. J. (*Jun., Oct. 2, 1889*)	Jan. 6, 1892
Rosener, Leland Sylvan. Cons. Engr., Merchants Exchange Bldg., San Francisco, Cal.	Jan. 31, 1911
Rosenthal, Albert. Pres., Pelham Bay Chemical Co., 699 Broadway, New York City. (*Jun., Jan. 2, 1894*)	Nov. 6, 1901
Rosewater, William Marcus. Engr., South Milwaukee Works, The Bucyrus Co., South Milwaukee, Wis.	June 5, 1901
Rosher, Edward Marshall. Chf. Engr., Cuban Central Rys., Ltd., Sagua la Grande, Cuba	Sept. 5, 1911
Ross, Thomas Alexander. P. O. Box 185, B. P. O., Shanghai, China	Dec. 3, 1902
Roundey, Eugene Peronneau. Care, Rapid Transit Ry., Syracuse, N. Y.	Jan. 6, 1904
Rousseau, Harry Harwood. Member, Isthmian Canal Comm.; Civ. Engr., U. S. N., Culebra, Canal Zone, Panama. (*Jun., June 6, 1893*)	April 4, 1900
Rousseau, William White. Supt. of Constr., Bureau of Water Supply, 47 State St., Troy, N. Y.	Dec. 1, 1908
Rowland, Walter. Junior Engr., Isthmian Canal Comm., Corozal, Canal Zone, Panama	Dec. 1, 1908
Ruckes, Joseph John, Jr. Engr., Barrett Mfg. Co., 1336 Bristow St., New York City	Jan. 31, 1911
Rue, Malcolm Asher. Chf. Engr., Robert Wilson Co., Engrs. and Contrs., 200 Fifth Ave., New York City	June 5, 1907
Rugg, Warren Fuller. Asst. Engr., N. Y. Board of Water Supply, 767 Elm St., Peekskill, N. Y.	Nov. 6, 1907
Ruggles, Charles Arner. Pres., Ruggles-Robinson Co., 331 Madison Ave., New York City	June 4, 1902
Runyon, William Kerper. Care, Amazon-Pacific Ry., Gayllarisquisga, Peru. (*Jun., April 5, 1898*)	Oct. 5, 1904
Rusch, Henri. 770 Bayard Ave., St. Louis, Mo.	Nov. 8, 1909
Rust, Henry Preston. Care, Vielé, Blackwell & Buck, 49 Wall St., New York City	Aug. 31, 1909
Ryan, Michael Healey. Care, Public Service Comm., 103 East 125th St., New York City. (*Jun., Dec. 3, 1901*)	April 1, 1908
Ryan, Walter J. 303 E. 6th St., York, Nebr. (*Jun., May 5, 1908*)	Mar. 1, 1910
Ryon, Henry. San. Engr., 626 Flatbush Ave., Brooklyn, N. Y.	Jan. 31, 1911
Sabin, Alvah Horton. Chemist, 432 Sanford Ave., Flushing, N. Y.	Mar. 4, 1896
Sackett, Robert Lemuel. Prof. of San. and Hydr. Eng., Purdue Univ.; Cons. Engr., Lafayette, Ind.	Feb. 6, 1907

ASSOCIATE MEMBERS S

	Date of Membership
Sadler, Carl Leon. Topographic Engr., U. S. Geological Survey, Washington, D. C.	April 1, 1908
St. Hill, Felix Perceval. Highbury, Longford, Tasmania	July 1, 1909
Sample, William Dwight. Pearson, Chihuahua, Mexico	Dec. 1, 1908
Sampson, Cornelius Bramhall. Alamosa, Colo	Oct. 5, 1909
Sanborn, James Forrest. Div. Engr., Board of Water Supply, New Paltz, N. Y	May 4, 1904
Sanborn, Morton Franklin. Asst. Engr., Board of Water Supply of New York City, P. O. Box 511, Pleasantville Station, N. Y	Mar. 1, 1910
Sanders, Francis Nicoll. 235 State St., Albany, N. Y	Sept. 3, 1902
Sanderson, Nathan Herbert. Asst. Engr. with Boston Bridge Works, Inc., 47 Winter St., Boston, Mass	Feb. 1, 1905
Sands, Edward Emmet. Powell, Wyo	Sept. 5, 1911
Sanford, Harry Charles. Treas. and Chf. Engr., Degnon Contr. Co., 60 Wall St., New York City	Oct. 5, 1898
Sanford, Walter Edward. 1016 East 2d St., Brooklyn, N. Y	Nov. 30, 1909
Sanger, Edmund Phipps. 261 Broadway, New York City	Feb. 2, 1909
Saph, Augustus Valentine. Asst. State Engr. with Board of State Harbor Commrs., San Francisco; 2330 Durant Ave., Berkeley, Cal. (*Assoc., Oct. 1, 1901*)	June 4, 1907
Sargent, Arthur Winthrop. U. S. Asst. Engr., Seattle, Wash	Sept. 6, 1905
Sargent, Joseph Andrews. Eng. Adviser, Northwest Co., Inc., 605 Lumberman's Bldg., Portland, Ore	Oct. 2, 1901
Sarr, Fred Winton. Div. Engr., N. Y. State Highway Dept., Griffin Bldg., Syracuse, N. Y	May 3, 1905
Saucedo, Vicente. Chf. Engr., Monterrey Elev. Ry., Light & Power Co., and Monterrey Water-Works & Sewer Co., P. O. Box 291, Monterey, N. L., Mexico. (*Jun., Oct. 6, 1903*)	May 3, 1910
Sauerman, Henry Burger. Coaling Station Engr., 914 East 66th St., Chicago, Ill	May 1, 1907
Saunders, Frank William. Dalles Celilo Canal Constr. Work, Big Eddy, Ore	Feb. 28, 1911
Saunders, George Crosby. With Dietrich Bros., Pleasant and Davis Sts., Baltimore, Md	Mar. 1, 1905
Saunders, Henry Jenness. Engr., Ford, Bacon & Davis, Valier, Mont., Land & Water Co., Valier, Mont	May 3, 1910
Saunders, Walter Bowen. Care, H. M. Byllesby & Co., Chicago, Ill	Jan. 4, 1910
Saurbrey, Henry Alexis d'Origny. Chf. Engr., Ransome Eng. Co., 90 West St., New York City (Res., 1117 West Front St., Plainfield, N. J.)	Jan. 2, 1912
Savage, John Lucian. With A. J. Wiley, 611 Idaho Bldg., Boise, Idaho	May 1, 1907
Savage, Seward Merrill. Treas., Alto Constr. Co., Holland Patent, N. Y.	April 1, 1908
Saville, Charles. With Rudolph Hering & John H. Gregory, 170 Broadway, New York City	June 30, 1911
Sawtelle, Harry Francis. Designing Engr., Cambridge-Main St. Subway, Boston Elev. Ry.; Res., 65 Dana St., Cambridge, Mass	Mar. 6, 1907
Sawyer, Donald Hubbard. Treas., Northwestern Eng. Corporation, General Delivery, Portland, Ore	April 6, 1909
Sawyer, Francis Murphy. Asst. Engr., Constr., P. R. R., Box 285, Swarthmore, Pa	June 6, 1906
Sawyer, George Loyal. Secy., Northwestern Eng. Corporation, 410 Lindelle Blk., Spokane, Wash	Jan. 8, 1908
Sawyer, Howard Lewden. Asst. Engr., The Harbor and Subway Comm. of Chicago, 108 South La Salle St., Room 1110, Chicago, Ill	Feb. 28, 1911
Sawyer, Wilbur Cyrus. Draftsman, City Engr.'s Office, 626 South Olive St., Los Angeles, Cal. (*Jun., Oct. 6, 1903*)	Sept. 6, 1905
Sayers, Edward Lawrence. With Noble & Woodard, Cons. Engrs., 7 East 42d St., New York City. (*Jun., Feb. 2, 1904*)	Jan. 3, 1911
Schaeffler, Joseph Carl. Archt. and Engr., 38 West 32d St., New York City. (*Jun., Feb. 28, 1905*)	June 5, 1907
Scharschmidt, Samuel Howard. 1327 Mason St., Elkhart, Ind	May 1, 1901
Scheidenhelm, Frederick William. Chf. Engr., Pittsburg Hydro-Elec. Co. and Mountain Park Land Co., Connellsville, Pa	June 6, 1911
Schermerhorn, Harvey Obed. Res. Engr., Residency No. 1, Erie Canal, Waterford, N. Y	Mar. 1, 1910
Scheuermann, Hugo Julius. Bridge Designer, Barge Canal Office, Albany, N. Y	Dec. 7, 1904
Schmitt, Ewald. Care, Light House Establishment, Office of Engrs., 12th Dist., Honolulu, Hawaii	Feb. 7, 1900
Schmitz, Frank Curtiss. Care, I. T. Williams & Sons, 25th St. and 11th Ave., New York City	Dec. 6, 1899
Schneider, Anton. Supt., Amalgamated Phosphate Co., Bartow, Fla	May 4, 1898
Schneider, Herman. Dean of the Eng. Coll., and Prof. of Civ. Eng., Univ. of Cincinnati, Cincinnati, Ohio	April 2, 1902
Schoder, Ernest William. Willard Ave., Ithaca, N. Y. (*Jun., Oct. 1, 1901*)	Jan. 2, 1907

	Date of Membership
Schrader, Frederick Adolph. Supt., John Monks & Sons, Inc., Gen. Contrs., 82 Beaver St., New York City	Jan. 4, 1910
Schreiber, Herman Victor. Managing Engr., Sellers & Rippey, 1301 Stephen Girard Bldg., Philadelphia, Pa	Mar. 1, 1910
Schubert, Charles Wesley. Structural Engr., Estimating Dept., The Brown Hoisting Machinery Co. (Res., 1357 East 110th St.), Cleveland, Ohio	Aug. 31, 1909
Schuchart, Paul August. Address unknown	Feb. 7, 1906
Schultz, Charles. Asst. City Engr., 619 South 23d St., Muskogee, Okla. (*Jun., Nov. 1, 1904*)	Sept. 5, 1911
Schuyler, Philip. 630 First National Bank Bldg., Oakland, Cal	May 31, 1910
Schwarze, Carl Theodore. Asst. Prof. of Civ. Eng., Cooper Inst., New York City (Res., 111 Sherman Pl., South Orange, N. J.)	May 1, 1907
Schwiers, Frederick William. 215 West 106th St., New York City. (*Jun., June 5, 1900*)	Jan. 7, 1903
Scott, Albert Lyon. 93 Federal St., Boston, Mass	Nov. 7, 1906
Scott, Charles Bruce. Asst. Engr., State Highway Comm., P. O. Box 181, Lynchburg, Va	Feb. 3, 1904
Scott, Guy. Div. Engr., Toledo Div., Penna. Lines West of Pitts., Toledo, Ohio. (*Jun., Dec. 1, 1903*)	Feb. 5, 1908
Scott, John Kuhn. Asst. Mgr., Operating Dept., Am. Water-Works & Guarantee Co., Pittsburgh (Res., 324 South Ave., Wilkinsburg), Pa. (*Jun., Oct. 1, 1907*)	Dec. 6, 1910
Scott, William Fry. Cons. Engr.; Archt., Drawer H, Dunnville, Ont., Canada	Oct. 7, 1908
Scrimshaw, James Frederick. Vice-Pres., Salmond Bros. Co., Gen. Contrs., 526 Elm St. (Res., 76 Bennett Ave.), Arlington, N. J	Jan. 8, 1908
Seabury, George Tilley. Asst. Engr. with Board of Water Supply, Valhalla (Res., 135 South Broadway, White Plains), N. Y. (*Jun., Mar. 31, 1903*)	Dec. 1, 1908
Seaman, William Henry. Glen Cove, N. Y	June 6, 1911
Searle, Charles Depew. Asst. Div. Engr., Public Service Comm., First Dist., 220 Cathedral Parkway, New York City	April 5, 1905
Searle, Lewen Firth. Asst. Engr., Board of Water Supply, New York City, Brown Station, N. Y	May 6, 1908
Sears, Robert Humphry. Dist. Engr., East Indian Ry., Calcutta, India	Dec. 4, 1901
Sears, Thomas Bartlett. Assoc. Prof. of Ry. Eng., Univ. of California, Berkeley, Cal	Oct. 5, 1904
Sears, Walton Harvey. With Lockwood, Greene & Co., 93 Federal St., Boston, Mass	April 5, 1910
Seastone, Charles Victor. Prin. Asst. to D. W. Mead, Cons. Engr., 530 State St., Madison, Wis	Dec. 5, 1906
Seaver, Clifford. Asst. Engr., Board of Water Supply, 165 Broadway, New York City	Dec. 6, 1910
Seery, Francis Joseph. Asst. Prof. of Civ. Eng., Coll. of Civ. Eng., Cornell Univ., 25 Willard Ave., University Pl., Ithaca, N. Y	April 3, 1907
Sekiba, Shigeki. Chf. Engr., Yokogawa Bridge Works, Sakaigawa St., Nishiku, Osaka, Japan	Oct. 2, 1907
Selmer, Jens Kristian. Sten Storegaten No. 6, Göteborg, Sweden	Nov. 7, 1906
Senior, Frank Sears. Chf. Engr., Arthur McMullen Co., Montgomery, N. Y. (*Jun., Feb. 28, 1899*)	Feb. 5, 1908
Senior, Samuel Palmer. Engr. and Supt., Bridgeport Hydr. Co., 820 Main St. (Res., 2121 North Ave.), Bridgeport, Conn	Oct. 7, 1903
Sesser, John Cornelious. Asst. Engr., M. of W., G. N. R. R. System, St. Paul, Minn. (*Jun., Sept. 5, 1899*)	April 1, 1903
Severson, Oscar Melvern. Asst. Engr., State Highway Comm., Falconer, Chautauqua Co., N. Y	Dec. 6, 1905
Sexton, Ralph Ernest. Care, Am. Bridge Co., Pencoyd, Pa	Oct. 3, 1911
Seyfert, Edgar Ernest. Chf. Engr., Pittsburgh Steel Products Co., 1902 Frick Bldg., Pittsburgh, Pa	July 9, 1906
Shafer, James Charles Forsythe. P. O. Box 93, Pine Bush, N. Y. (*Jun., Oct. 6, 1908*)	May 2, 1911
Shaner, Harry Linden. City Engr.; Chf. Engr., Gravity Water Supply, Lynchburg, Va	Dec. 7, 1904
Shannon, William Day. Care, Stone & Webster Eng. Corporation, Sumner, Wash	Dec. 5, 1911
Shaughnessy, Charles Stephen. Asst. Engr., Board of Water Supply, City of New York, Cold Spring-on-Hudson, N. Y	June 6, 1911
Shaw, David Joseph. Chappaqua, Westchester Co., N. Y. (*Jun., April 4, 1905*)	Mar. 6, 1907
Shaw, Frank Harold. Engr., Water and Sewer Commissions, 503 Woolworth Bldg., Lancaster, Pa	Oct. 4, 1905
Shaw, George Herbert. Asst. Engr., Board of Water Supply of New York City, 165 Broadway, New York City	April 5, 1910
Shaw, William Thomas. Greencastle, Pa	June 30, 1910
Shearer, Charles English. Cons. Structural Engr., Randolph Bldg., Memphis, Tenn	Dec. 6, 1910

	Date of Membership
Shedd, George Garnett. Supt. and Engr., J. G. White & Co., Inc., 43 Exchange Pl., New York City	Oct. 3, 1906
Sheffield, Edward Newton. Irrig. Engr., 1325 Grant St., Denver, Colo.	April 5, 1910
Sheldon, Charles Smith. First Asst. Engr., C., H. & D. Ry., Cincinnati, Ohio	June 7, 1905
Sheldon, Paul. Treas., Ford, Buck & Sheldon, Inc., 60 Prospect St., Hartford, Conn	Oct. 5, 1909
Sheley, Horace West. Cons. Engr., 910 Kearns Bldg., Salt Lake City, Utah. (*Jun., Sept. 5, 1905*)	July 1, 1909
Shellenberger, Leidy Rudy. With Public Service Comm., Tribune Bldg., New York City (Res., 19 East 42d St., Bayonne, N. J.)	May 2, 1900
Shelmire, Robert Warren. 2752 North 12th St., Philadelphia, Pa	Nov. 30, 1909
Shema, Joseph. Dept. of Bridges, P. R. R., Lines West, Union Station, Pittsburgh, Pa. (*Jun., Oct. 3, 1905*)	June 6, 1911
Shepardson, John Eaton. Res. Engr., Carolina, Clinchfield & Ohio Ry. (Res., 514 East Wataugo Ave.), Johnson City, Tenn	Jan. 7, 1903
Shepperd, Thomas Shackelford. Cons. Engr., Littleton, Colo	June 30, 1911
Shertzer, Tyrrell Bradbury. Asst. Engr., Public Service Comm. for First Dist., 565 Fifth Ave., Brooklyn, N. Y.	Oct. 5, 1904
Shipman, Charley Evans. Supt., Water-Works, and City Engr., Laurel, Mont. (*Jun., April 3, 1906*)	Nov. 4, 1908
Shire, Moses Edmund. Gen. Supt., Hirsh Stein & Co., Hammond, Ind. (*Jun., April 2, 1901*)	Jan. 4, 1905
Shoecraft, Ezra Collin. City Engr., La Porte, Ind	Sept. 6, 1910
Shoemaker, Harry Ives. Div. Engr., Manila Ry. Co., Ltd., Manila, Philippine Islands	May 4, 1909
Shoemaker, John Earl. Designing and Constr. Engr., Pueblo-Rocky Ford Irrig. Co., 601 North Main St., Pueblo, Colo	June 6, 1911
Shortt, John Haggerty. 11 Wilton Crescent, Toronto, Ont., Canada	June 7, 1905
Shryock, Joseph Grundy. Designing Engr., Belmont Iron Works, 22d St. and Washington Ave., Philadelphia, Pa. (*Jun., April 2, 1901*)	Dec. 5, 1906
Shutts, Fred Ordway. Asst. Engr., Board of Public Works, 1309 Guerrero St., San Francisco, Cal	Oct. 3, 1911
Sickman, Albert Franklin. Hydr. Engr., Holyoke Water Power Co., Holyoke, Mass	Mar. 4, 1903
Sidenius, Harry. Res. Engr., C. P. Ry., Irrig. Dept., Bassano, Alta., Canada	Jan. 2, 1912
Sikes, Zenas Harrison. Asst. Engr. of Structures, N. Y. C. & H. R. R. R., Grand Central Terminal, New York City (Res., 333 Riverdale Ave., Yonkers, N. Y.)	June 30, 1910
Simpson, Erastus Roland. 89 St. Bololph St., Boston, Mass	Nov. 4, 1903
Simpson, George. Chf. Engr., Thompson-Starrett Co., 51 Wall St., New York City	April 4, 1900
Simpson, Paul Dyer. Field and Cons. Engr., Bangor Power Co., Bangor Ry. & Elec. Co., Bangor, Me	Feb. 6, 1907
Sims, Stuart. Gen. Mgr., Catlettsburg, Kenova & Ceredo Water Co., Ashland Water-Works Co., Ashland, Ky	July 1, 1909
Sinnickson, George Rosengarten. Penna. R. R. Office, Williamsport, Pa. (*Jun., Sept. 5, 1899*)	Feb. 6, 1907
Sinz, Edward Frederick. (Donohue & Sinz), 704 North 8th St., Sheboygan, Wis	Sept. 5, 1911
Sisson, George Arthur. Supt., Div. 3, Dalles-Celilo Canal, Big Eddy, Ore. (*Jun., April 30, 1907*)	Oct. 5, 1909
Sitt, William Theodore. Cons. Engr., Wells Bros. Co. of New York, 366 Fifth Ave., New York City	June 7, 1905
Skelly, James William. Asst. Engr., U. S. Engr. Office, Custom House, St. Louis, Mo. (*Jun., May 2, 1899*)	April 1, 1903
Skillin, Edward Simeon. Second Vice-Pres., The Snare & Triest Co., 143 Liberty St., New York City	Dec. 1, 1908
Skinner, Frederick Gardiner. 2103 Carey Ave., Cheyenne, Wyo	Sept. 4, 1907
Skorniakoff, Eugene Eugenievich. Dept. of Irrig., Ministry of Agri., St. Petersburg, Russia	May 2, 1911
Slattery, Lawrence Patrick. Asst. Engr. with J. E. Sirrine, Greenville, S. C	Feb. 1, 1910
Slayton, Charles Albert. Care, Corrigan & Halpin Constr. Co., 712 Southwest Boulevard, Kansas City, Mo	April 2, 1902
Slocum, Curlys Lyon. Res. Engr., Constr., New Bridge Shop, St. Lawrence Bridge Co., 59 St. Peters St., Montreal, Que., Canada. (*Jun., Jan. 3, 1905*)	July 9, 1906
Slocum, Harry Spencer. Care, Vielé, Blackwell & Buck, Grayson, Va	Nov. 1, 1910
Smiley, Grier Ralston. Moffatts Creek, Va	April 1, 1908
Smith, Albert. Civ. and Min. Engr., Saltsburg, Pa	Jan. 6, 1892
Smith, Albert Henry. Cons. Engr., 322 The Nasby, Toledo, Ohio	Oct. 2, 1901
Smith, Albert Orange. Civ. and Landscape Engr.; Supt. of Highways, Suffolk County, Port Jefferson, N. Y. (*Jun., May 2, 1905*)	Feb. 2, 1909
Smith, Charles Bailey. 516 Empire Bldg., Boise, Idaho	Jan. 3, 1906

	Date of Membership
Smith, Charles Vernon. Asst. Engr., L. V. R. R., 90 West St., New York City	Dec. 5, 1906
Smith, Chester Alexander. 823 Scarritt Bldg., Kansas City, Mo	April 5, 1910
Smith, Chester Wason. Pulaski, N. Y	Oct. 5, 1904
Smith, Claiborne Ellis. 508 Parrett St., Evansville, Ind	Dec. 5, 1911
Smith, Courtland Elmore. Asst. Engr., Dept. of Water Supply, Gas and Electricity, 13 Park Row, New York City (Res., 174 Prospect Pl., Brooklyn, N. Y.)	Mar. 1, 1905
Smith, Donald David. Cons. Engr., Southern Surety Co., New National Bank of Commerce Bldg., St. Louis, Mo	Sept. 6, 1910
Smith, Edgar Field. Asst. Prof. of Civ. Eng., Polytechnic Inst. of Brooklyn; 408 West 130th St., New York City	May 1, 1907
Smith, Edgar Maverick. M. of W., Device & Eng. Co., 9 East 30th St., New York City	Dec. 2, 1903
Smith, Edward St. Clair. County Engr. and Director of Highways, Gooding, Idaho	Dec. 6, 1910
Smith, Eliot Nichols. High Falls, N. Y. (*Jun., April 2, 1907*)	June 30, 1910
Smith, Forrest Leigh. Township Engr., 102 Smith St., Perth Amboy, N. J. (*Jun., April 30, 1907*)	Nov. 8, 1909
Smith, George Edson Philip. Irrig. Engr., Univ. of Arizona, Tucson, Ariz. (*Jun., Feb. 3, 1903*)	Sept. 6, 1905
Smith, Julian Chatard. Pres. and Mgr., Vacuum Specialty Co., 624 First Ave., New York City	Oct. 2, 1907
Smith, Karl Garthwaite. Contr. Engr., 671 Broad St., Newark, N. J.	May 3, 1910
Smith, Lloyd Bown. Engr., The Topeka Bridge & Iron Mfg. Co., Topeka, Kans	April 6, 1904
Smith, Marion deKalb, Jr. 6 Washington Ave., Chestertown, Md. (*Jun., Oct. 1, 1901*)	Sept 5, 1911
Smith, Pemberton. South American Representative, U. S. Steel Products Export Co., 544 Bartolomé Mitre, Buenos Aires, Argentine Republic. (*Jun., Mar. 31, 1891*)	April 4, 1894
Smith, Russell Biddle. Pres., Russell B. Smith, Inc., 17 Madison Ave., New York City	May 6, 1908
Smith, Thomas Arthur. Gen. Supt., Turner Constr. Co., 11 Broadway, New York City	April 6, 1909
Smith, Travis Logan, Jr. Civ. Engr. and Surv., Eagle Lake, Tex. (*Jun., Feb. 3, 1903*)	Nov. 4, 1908
Smith, Walter Dorr. 4210 Gordon Ave., Los Angeles, Cal	June 30, 1911
Smith, William Beauvais, Jr. U. S. Junior Engr., U. S. Engr. Office, Custom House, New Orleans, La	June 30, 1911
Smith, William Ernest. 401 Terminal Bldg., Oklahoma, Okla	Dec. 1, 1908
Smith, William Stuart. Dist. Mgr., Warren Bros. Co., 49 West Ave., Rochester, N. Y	Jan. 8, 1902
Smith, Wilson Fitch. Div. Engr., Board of Water Supply of City of New York, Valhalla, N. Y. (*Jun., Jan. 3, 1895*)	May 1, 1901
Smoley, Constantine Kenneth. Prin. of School of Civ. Eng., International Correspondence Schools, Scranton, Pa	June 30, 1910
Snell, Harry Bronson. 315 Lafayette Ave., Brooklyn, N. Y	Dec. 5, 1906
Snell, Joseph Emmett. 247 North 6th St., Newark, N. J	April 5, 1910
Snell, Roy Martin. Project Engr., U. S. Reclamation Service, Helena, Mont	Sept. 6, 1910
Snodgrass, Robert Davis. Chf. Engr., Trussed Concrete Steel Co., Detroit, Mich	Jan. 2, 1912
Snyder, Charles Herman. City Engr., City Hall, Oswego, N. Y. (*Jun., Oct. 7, 1902*)	July 9, 1906
Snyder, Frederic Antes. Res. Mgr. and Secy., Cuban Eng. & Contr. Co., Arsenal 2, Havana, Cuba	June 1, 1904
Solomon, Gabriel Roberts. (Solomon-Norcross Co.), 1622 Candler Bldg., Atlanta, Ga	Oct. 2, 1907
Soper, Ellis Clark. Pres., The Soper Co., James Bldg., Chattanooga, Tenn	Dec. 5, 1906
Soulé, Edward Lee. Structural Engr., 2532 Hillegas Ave., Berkeley, Cal. (*Jun., April 3, 1906*)	Jan. 4, 1910
Souther, Theodore Wheeler. 578 Newbury St., Boston, Mass	Mar. 6, 1907
Southworth, Edward Augustus. County Engr. of Hawaii, Hilo, Hawaii	July 1, 1909
Sparrow, William Warburton Knox. Care, Waddell & Harrington, Orear-Leslie Bldg., Kansas City, Mo	Dec. 6, 1905
Spaulding, Frank Alger. 27 Pomeroy Ave., Pittsfield, Mass	Jan. 31, 1911
Spear, Philip Hichborn. Asst. Engr., N. Y. C. & H. R. R. R.; Res., Hastings-on-Hudson, N. Y. (*Jun., Dec. 5, 1905*)	Feb. 5, 1908
Spearman, Charles. Cons. Hydr. and Irrig. Engr., Room 210, Boise City National Bank Bldg., Boise, Idaho	Oct. 5, 1909
Speicher, Pius Melanthon. Contr., Chandler, Okla	Nov. 7, 1906
Spelman, John Rodgers. Cons. Engr., 125 East 23d St., New York City (Res., 60 Cedar St., Rockville Center, N. Y.)	Dec. 6, 1910

	Date of Membership
Spencer, Frank Morton. Mgr., Eastern Dept., Leonard Constr. Co., McCormick Bldg., Chicago, Ill.	June 30, 1910
Spencer, Herbert. Engr., Standard Oil Co. of New Jersey, 26 Broadway, New York City. (*Jun., Feb. 2, 1904*)	Mar. 4, 1908
Spencer, Louis Bernard. Civ. and Min. Engr., Hawthorne, Nev. (*Jun., Oct. 31, 1899*)	Nov. 8, 1909
Spencer, Theodore Nelson. Asst. Engr., Dept. of Public Works, 4903 Cedar Ave., Philadelphia, Pa.	Sept. 5, 1900
Spencer, Walter Tuttle. Div. Engr., N. Y., N. H. & H. R. R., Waterbury, Conn. (*Jun., May 2, 1893*)	Oct. 4, 1899
Spengler, Albert. Gen. Supt., National Constr. Co., 2626 Holly St., Denver, Colo.	May 6, 1908
Spielman, John Godfrey. 4128 North Hermitage Ave., Chicago, Ill. (*Jun., Mar. 4, 1891*)	May 1, 1895
Spiker, William Clare. Forsyth Bldg., Atlanta, Ga.	June 5, 1907
Spitzer, Felix Henry. First National Bank Bldg., 4th Floor, Kansas City, Mo.	June 30, 1911
Splitstone, Charles Harold. Chf. Draftsman, Erie R. R., 9 Girard Ave., East Orange, N. J. (*Jun., Sept. 5, 1905*)	Oct. 5, 1909
Squire, Harry Edwin. Engr. for Erickson Constr. Co., 924 Highland Ave., Bremerton, Wash. (*Jun., Jan. 3, 1907*)	June 6, 1911
Stabler, Herman. Asst. Engr., Water Resources Branch, U. S. Geological Survey, Washington, D. C.	Nov. 1, 1910
Stanford, Albert Franklin. (Lowrance Bros. & Co.), 1432 Court St., Memphis, Tenn.	June 30, 1911
Stansbury, Herbert Earl. Asst. Engr., E. P. & S. W. Sys., Tucumcori, N. Mex.	May 3, 1910
Stanton, Fred Caswell. Asst. Engr., Isthmian Canal Comm., Cristobal, Canal Zone, Panama	April 1, 1908
Stanton, Wilbor Dickens. Junior Engr., Isthmian Canal Comm., Las Cascadas, Canal Zone, Panama. (*Jun., Oct. 2, 1906*)	May 3, 1910
Starr, Frank Charles. Asst. Prof., Civ. Eng., George Washington Univ.; Architectural Engr. (Mechlin & Starr), 1530 Eye St., N. W., Washington, D. C.	Sept. 5, 1911
Starr, Herbert Harris. Care, Am. Bridge Co., 30 Church St., New York City	Oct. 2, 1907
Stearns, Edward Burnham. Asst. Div. Contr. Mgr., Am. Bridge Co. of N. Y., 30 Church St., New York City	June 1, 1898
Stearns, Fred Lincoln. Dist. Supt. of Street Cleaning, Scarsdale, N. Y. (*Assoc., June 3, 1902*)	Jan. 31, 1905
Stearns, Ralph Hamilton. Div. Engr., Board of Water Commrs., Hartford, Conn.	Dec. 4, 1907
Steere, Anthony Enoch. Res. Engr., Barge Canal Office, Waterloo, N. Y.	April 1, 1908
Steffens, William Frederick. Engr. of Structures, B. & A. R. R., South Station, Boston, Mass. (*Jun., April 3, 1900*)	Oct. 1, 1902
Stegner, Clifford Milton. Cons. Engr., 615 Mercantile Library Bldg., Cincinnati, Ohio	May 2, 1911
Stehle, Felix Charles. With Am. Bridge Co., Brooklyn Plant; Res., 421 South Columbus Ave., Mt. Vernon, N. Y.	June 3, 1903
Stellhorn, Adolf. Civ. Engr., War Dept., U. S. A., 1312 South 2d St., Leavenworth, Kans.	May 2, 1911
Stengel, Carl Henry. Office Engr., L. V. R. R., 90 West St. (Res., 2674 Jerome Ave., Fordham), New York City	Oct. 3, 1906
Stenger, Ernest. Gen. Mgr., St. Joseph & Grand Is. Ry., St. Joseph, Mo.	June 5, 1895
Stepath, Charles Underhill. Olive Bridge, Ulster Co., N. Y. (*Jun., Feb. 3, 1903*)	July 10, 1907
Stephens, Allen Whitmore. Designing Engr., Turner Constr. Co., 8 Birchwood Ave., East Orange, N. J.	June 6, 1911
Stephenson, Frank Henry. Asst. Engr., Filtration Div., Dept. of Water Supply, Gas and Electricity, New York City	Jan. 8, 1908
Stephenson, Stuart Augustus, Jr. Instr. in Math. and Graphics, Rutgers Coll. (Res., 266 Redmond St.), New Brunswick, N. J. (*Jun., Jan. 3, 1905*)	July 10, 1907
Sterns, Frank Ernest. Care, Chf. Engr., Culebra, Canal Zone, Panama	Jan. 2, 1912
Stevens, Arthur Leslie. Asst. Engr., Sewer Maintenance Dept., 319 City Hall (Res., 5600 Linwood Ave.), Cleveland, Ohio	Oct. 31, 1911
Stevens, Elihu William. Care, F. R. Long Co., Hackensack, N. J.	April 6, 1909
Stevens, George M. 35 Sagamore Ave., Winthrop, Mass.	Nov. 6, 1907
Stevens, Harold Converse. Asst. Engr. Designer, New York Board of Water Supply, 165 Broadway, New York City	June 30, 1910
Stevens, Harold Lyell. 1109 Karpen Bldg., Chicago, Ill.	April 6, 1909
Stevens, John Cyprian. Civ. and Hydr. Engr., Spalding Bldg., Portland, Ore.	April 1, 1908
Stevens, Perley Egbert. Engr., Butler Bros. (Res., 1802 Hague Ave.), St. Paul, Minn. (*Jun., April 6, 1897*)	April 2, 1902

	Date of Membership
Stevenson, Thomas Patton, Jr. Engr., Rio Janeiro Tramway, Light & Power Co., Caixa Correio 1012, Rio de Janeiro, Brazil. *(Jun., April 4, 1905)*	Nov. 6, 1907
Stevenson, William Freeman. 605 West 178th St., New York City	Oct. 5, 1904
Stevenson, William Lawrie. Asst. Engr., Sewage Disposal Works, Bureau of Surveys, 412 City Hall, Philadelphia, Pa	Oct. 2, 1907
Stewart, Benjamin Franklin, Jr. City Engr., Parkersburg, W. Va	Dec. 5, 1911
Stewart, Clinton Brown. Cons. Hydr. Engr., Wisconsin Bldg., Madison, Wis	Oct. 5, 1898
Stewart, John. Pres. and Treas., The Crawford Constr. Co., Gerke Bldg., Cincinnati, Ohio	Nov. 4, 1908
Stewart, John Truesdale. Chf. of the Div. of Agri. Eng., Univ. of Minnesota, University Farm, St. Paul, Minn	Sept. 6, 1905
Stewart, John Wellington. Roswell, N. Mex	Jan. 2, 1907
Stewart, Spencer James. Div. Engr., Div. No. 1, New York State Highway Comm., Poughkeepsie, N. Y	June 7, 1899
Stidham, Harrison. Secy. and Mgr., Washington Fertilizer Co., Hibbs Bldg., Washington, D. C	April 4, 1900
Stiles, Otho William. City Engr., 120 West Corwin St., Circleville, Ohio.	Dec. 6, 1910
Stocking, Jerome Branch. Asst. Chf. Engr., Salmon River Canals, Hollister, Idaho	Jan. 2, 1912
Stockman, Louis Richard. Engr., The Laramie-Poudre Reservoirs & Irrig. Co., 820 West Olive St., Fort Collins, Colo	July 9, 1906
Stockton, John. 253 Nassau St., Princeton, N. J	Sept. 6, 1905
Stockton, Robert Summers. Supt. of Irrig., C. P. Ry., Irrig. Dept., Strathmore, Alta., Canada	April 6, 1909
Stoddard, Raymond French. Cons. Engr., 83 Fairfield Ave., Bridgeport, Conn	Jan. 3, 1906
Stone, Willard Wilberforce. Asst. Engr., Board of Water Supply, City of New York, 146 Montgomery St., Newburgh, N. Y	Feb. 7, 1906
Storer, Stacy Steward. Structural Engr., Care, Superv. Archt.'s Office, Treasury Dept., Washington, D. C	Nov. 4, 1908
Stout, Homer Harding. 2412 Monterey St., San Antonio, Tex	Oct. 7, 1908
Stowitts, George Putnam. Chf. Draftsman, N. Y. C. & H. R. R. R., Room 5140, Grand Central Terminal (Res., 3168 Decatur Ave.), New York City	June 3, 1908
Strathmann, Edward Charles. Gen. Supt., Bedford Stone & Constr. Co., 814 Traction Bldg., Indianapolis, Ind	Nov. 8, 1909
Stratton, George Eber. Engr., U. S. Reclamation Service, Helena, Mont.	Jan. 8, 1902
Strawn, Thomas Corwin. Supt. for W. B. Waldo, 355 West 55th St., New York City. *(Jun., Nov. 5, 1901)*	June 3, 1903
Strickler, Frederick Wineman. 448 Walnut St., Meadville, Pa	Dec. 6, 1910
Strickler, Thomas Johnson. Public Utilities Comm., State of Kansas, Topeka, Kans	May 3, 1910
Stromberg, Julian Willis. 342 River St., Chicago, Ill	Jan. 2, 1912
Strong, Archibald McClure. Min. and Civ. Engr., 418 Merchants Trust Bldg., Los Angeles, Cal	Jan. 8, 1908
Strong, James Boorman. Asst. Gen. Mgr., Ramapo Iron Works, Hillburn, N. Y	Oct. 5, 1904
Strong, William Edward Schenck. Cons. Engr., 31 Nassau St., New York City	April 6, 1898
Stuart, James Lyall. Const. Engr., 609 H. W. Oliver Bldg., Pittsburgh, Pa. *(Jun., Oct. 4, 1898)*	Feb. 7, 1900
Stubblefield, Garfield. Cons. Engr. (Whistler & Stubblefield), U. S. National Bank Bldg., Portland, Ore	Nov. 6, 1907
Studwell, Chester Arthur. Village Engr., Port Chester, N. Y	Oct. 31, 1911
Sturgeon, George Blair. Engr. in Chg. of Constr. of Greater Univ. Roads and Bldgs., Constr. Office, Univ. of California, Berkeley, Cal.	May 31, 1910
Suarez y Cordoves, Patricio Andres. Central "Esperanza," Calimete, Cuba. *(Jun., April 6, 1909)*	Nov. 1, 1910
Sudler, Emory. Engr. in Chg., Gunpowder Supply, Impvt. Div., Baltimore City Water Dept., Knickerbocker Bldg., Baltimore, Md	Sept. 5, 1911
Sudriers, Victor Boureau. Agraciada 633, Montevideo, Uruguay	Oct. 3, 1906
Sullivan, John Francis. Asst. Engr., Office of Cons. Engr., Borough of Manhattan (Res., 241 West 108th St.), New York City	Jan. 4, 1910
Sullivan, Murray. Office Engr., Ore. Short Line R. R., Salt Lake City, Utah	Sept. 6, 1910
Sullivan, Vernon Lyle. Buenavista, Tex	June 6, 1911
Sussex, James Wolfe. Archt. and Engr., Wenatchee, Wash. *(Jun., Oct. 6, 1903)*	Oct. 2, 1907
Suter, Russell. Asst. Engr., New York State Conservation Comm., Albany, N. Y	Jan. 2, 1907
Sutton, Charles Wood. Chf. Engr., Peruvian Irrig. Service, Lima, Peru. *(Jun., Dec. 1, 1903)*	Dec. 6, 1905
Swanitz, Henry Wade. Asst. City Engr., 1390 Seventh Ave., San Francisco, Cal	May 2, 1911

	Date of Membership
SWARTWOUT, ROY ADOLF. Vice-Pres. and Gen. Mgr., Western Bridge & Constr. Co., 648 Bee Bldg., Omaha, Nebr. (*Jun., May 2, 1905*)	July 1, 1909
SWATY, DAVID YOUNGS. Engr. with Great Lakes Dredge & Dock Co., 1148 Oliver Bldg., Boston, Mass. (*Jun., Oct. 6, 1903*)	Oct. 3, 1906
SWEENEY, HARRY CLINTON. Cons. Engr., 11 Broadway, New York City	July 1, 1909
SWEENEY, JOHN BERNARD. 703 East Park Way, McKeesport, Pa. (*Jun., Feb. 4, 1908*)	Oct. 3, 1911
SWEITZER, NELSON BOWMAN. U. S. Superv. of Surveys, Nebraska and South Dakota, Neligh, Nebr. (*Jun., Feb. 28, 1893*)	Mar. 1, 1899
SWENDSEN, WARREN G. (Swendsen, Swendsen & Peirce), 27 Shaw Blk., Boise, Idaho	Dec. 6, 1910
SWICKARD, ANDREW. Res. Engr., South San Joaquin Irrig. Dist., Oakdale, Cal	June 6, 1906
SWINDELLS, JOSEPH SPRINGER. Cons. Engr., 1090 East 18th St., Brooklyn, N. Y. (*Jun., Feb. 2, 1897*)	Mar. 2, 1904
SYKES, GEORGE. Bldg. Constr., 1123 Broadway, New York City. (*Jun., May 1, 1906*)	Dec. 4, 1907
SYKES, GEORGE WHITFIELD. Div. Engr., Port Boliver Iron Ore Ry., Box 145, Gilmer, Tex. (*Jun., April 30, 1895*)	Dec. 1, 1897
SYLVESTER, ALBERT HALE. Forest Supervisor, Wenatchee National Forest, Leavenworth, Wash	June 7, 1905
TAFT, JESSE RUSSELL. Supt., W. H. Coverdale & Co., Inc., Greigsville, N. Y. (*Jun., June 2, 1903*)	Sept. 6, 1905
TAGGART, RALPH CONE. World Bldg., New York City	Oct. 5, 1904
TAIT, HAROLD. Bureau of Sewers, Hackett Bldg., Long Island City, N. Y.	May 7, 1902
TAIT, JOHN GEORGE. Metuchen, N. J	May 6, 1896
TALBOT, EARLE. New York State Res. Engr., Impvt. of Erie Canal, 196 Genesee St., Utica, N. Y. (*Jun., Nov. 1, 1904*)	Mar. 4, 1908
TALLMAN, LEROY. Supt., Pittsburgh Contr. Co., Elmsford, N. Y	Feb. 2, 1909
TALLMAN, PAUL BERTRAM. Engr. for Warren & Wetmore, 3 East 33d St., New York City. (*Jun., Oct. 3, 1905*)	Sept. 6, 1910
TARR, CHARLES WINTHROP. Asst. Engr., Dept., Water Supply, Gas and Electricity, New York City (Res., 10 Orange St., Brooklyn, N. Y.)	June 6, 1906
TARVER, THOMAS CARY, JR. Houston, Tex	Sept. 6, 1910
TAYLOR, ALEXANDER JENIFER. City Engr., Wilmington, Del. (*Jun., Oct. 3, 1899*)	April 3, 1907
TAYLOR, EDWARD BALLINGER, JR. Div. Engr., Pennsylvania Lines, Logansport, Ind	Sept. 6, 1910
TAYLOR, JACKSON, JR. Swarthmore, Pa	Oct. 7, 1908
TAYLOR, JOHN. 176 Metcalfe St., Ottawa, Ont., Canada	May 2, 1911
TAYLOR, OLIVER KIRK, JR. City Engr. and Surv., 767 East Maiden St., Washington, Pa	May 6, 1908
TAYLOR, WARREN CROSBY. Instr. in Civ. Eng., Union Coll., Schenectady, N. Y. (*Jun., Feb. 4, 1908*)	Dec. 5, 1911
TAYLOR, WILLIAM PURVES. Engr. in Chg. of Philadelphia Municipal Testing Laboratories, 318 City Hall, Philadelphia, Pa. (*Jun., Oct. 7, 1902*)	May 4, 1909
TAYLOR, WYLLYS HARD. Acting Dist. Engr., Dumaguete, Oriental Negros, Philippine Islands	Oct. 3, 1911
TEBBETTS, GEORGE EDWARD. Bridge Engr., Kansas City Terminal Ry., 23d St. and Grand Ave., Kansas City, Mo	Jan. 4, 1910
TENNEY, WILLIAM FIELD. Asst. Engr., N. Y. C. & H. R. R. R. (Res., 15 West St.), Utica, N. Y	Nov. 1, 1910
TERRY, ALFRED HOWE. City Engr., Bridgeport, Conn	June 6, 1906
TERRY, ARTHUR LINVILLE, JR. Secy. and Treas. (Hungerford & Terry), 1414 Penna. Bldg., Philadelphia, Pa. (*Jun., Mar. 5, 1907*)	June 30, 1910
THANHEISER, CHARLES AUGUST. Asst. Supt., T. & N. O. R. R., Houston, Tex	July 10, 1907
THAYER, HORACE RICHMOND. Asst. Prof. of Structural Design, Carnegie Technical Schools, 6529 Aylesboro Ave., Pittsburgh, Pa	Mar. 7, 1906
THEBAN, JOHN GERARD. Engr. in Chg. of Dept. of Bridges, Borough of the Bronx, 428 East 133d St., New York City	Mar. 3, 1897
THEODORSON, WILLIAM ANTON. With Terminal Engr., C. & N. W. Ry., Jackson Boulevard and Franklin St., Chicago, Ill	Oct. 7, 1908
THOMA, JACOB. Bureau of Sewers, Hackett Bldg., Long Island City, N. Y	Oct. 7, 1908
THOMAS, CHARLES DURA. Asst. Engr., Public Service Comm., First Dist., 23 Flatbush Ave. (Res., 547 Carlton Ave.), Brooklyn, N. Y	Jan. 8, 1908
THOMAS, EDGAR BRANSON. Chf. Draftsman, Office of City Civ. Engr. (Res., 11417 Glenwood Ave., S. E.), Cleveland, Ohio	June 3, 1908
THOMAS, RALPH DANFORD. Asst. Engr., Minneapolis Mill Co., Minneapolis, Minn	May 6, 1908
THOMAS, WILLIAM EDWARD. 86 Jaggar Ave., Flushing, N. Y	July 1, 1909
THOMAS, WILLIAM MICHAEL. Care, Young Constr. Co., 12th Floor, Union Trust Bldg., Los Angeles, Cal	Nov. 8, 1909

	Date of Membership
Thomes, Edward Calderwood. City Engr.; (Raudabaugh & Thomes), Poplar Bluff, Mo	Dec. 5, 1911
Thompson, Clarence Hard. Structural Engr., The Solvay Process Co., 209½ Sabine St., Syracuse, N. Y	Sept. 7, 1904
Thompson, Clark Wallace. Vice-Pres., Wind River Lumber Co., Cascade Locks, Ore. (*Jun., Mar. 5, 1890*)	July 3, 1895
Thompson, Edward Percival. Chf. Engr., Mindoro Development Co., 970 Calle Real, Manila, Philippine Islands. (*Assoc., June 5, 1907*)	Sept. 5, 1911
Thompson, Mackey James. 514 Pioneer Press Bldg., St. Paul, Minn	Oct. 7, 1903
Thomson, Alexander, Jr. Div. Engr., Board of Water Supply, Walden, Orange Co., N. Y. (*Jun., Dec. 4, 1900*)	Feb. 3, 1904
Thomson, Samuel Forsythe. Asst. Engr., Board of Water Supply of New York City, New Paltz, N. Y	Jan. 3, 1906
Thomson, Warren Brown. Asst. Engr., B. & A. R. R., The Granite Bldg., Springfield, Mass. (*Jun., Feb. 5, 1907*)	April 4, 1911
Thon, George Louis. Asst. Engr., Alvord & Burdick, 1417 Hartford Bldg., Chicago, Ill	Oct. 3, 1911
Thorn, Columbus William. Asst. Engr., Constr., P. R. R., Market St. Ferries, Philadelphia, Pa	July 9, 1906
Thrane, Martin Mathias. Engr., Bldg. Dept., Gen. Elec. Co., Pittsfield, Mass	Jan. 8, 1908
Throop, Augustus Thompson. Gen. Mgr., Elec. Dept., Utica Gas & Elec. Co., 222 Genesee St., Utica, N. Y. (*Jun., Oct. 3, 1893*)	Mar. 3, 1897
Throop, George Huntington. Care, J. G. White & Co., 43 Exchange Pl., New York City	May 1, 1907
Throop, Henry Grosvenor. Engr. of Constr., Oneida Ry., Syracuse R. T. Ry., Utica & Mohawk Val. Ry., 1608 South Geddes St., Syracuse, N. Y	June 30, 1911
Thuringer, Charles. 430 State St., Madison, Wis	Mar. 4, 1908
Tibbetts, Frank Leslie. Asst. Engr., East Boston Co., 19 Congress St., Boston, Mass	Jan. 4, 1910
Tibbetts, Frederick Horace. Alaska Commercial Bldg., San Francisco, Cal. (*Jun., May 1, 1906*)	April 6, 1909
Tidd, Arthur Warren. Section Engr., New York City Board of Water Supply, Hill View Div., Yonkers (Res., White Plains), N. Y	June 3, 1903
Tilden, Charles Joseph. Prof., Eng. Mechanics, Univ. of Michigan, 1619 Cambridge Rd., Ann Arbor, Mich. (*Jun., May 31, 1898*)	Feb. 5, 1902
Tillinghast, Frederick Howard. Res. Engr., Lahontan Dam, U. S. Reclamation Service, Lahontan, Nev	May 1, 1907
Tilmont, Paul Alphonse Gaillard. Track and Ballast Engr., N. P. Ry., Kelso, Wash	July 1, 1909
Tilt, Garret Edward. Chf. Engr., Structural Dept., Care, John Monks & Sons, 82 Beaver St., New York City	June 1,1909
Tinkham, Ralph Russell. Asst. Supt. of Lighthouses, 11th Dist., 346 Post Office Bldg., Detroit, Mich. (*Jun., Oct. 3, 1905*)	Sept. 6, 1910
Tisdale, Charles Harry. U. S. Junior Engr., Guild, Tenn	Oct. 31, 1911
Titsworth, Ralph Bentley. Contr. Engr., McClintic-Marshall Constr. Co., 58 Lafayette Boulevard, Detroit, Mich	Dec. 1, 1908
Toltz, Max. 1614 Pioneer Bldg., St. Paul, Minn	Sept. 7. 1892
Tombo, Carl. 321 St. Nicholas Ave., New York City. (*Jun., Feb. 3, 1903*)	Jan. 4, 1910
Tompkins, Charles Hook. Engr. and Contr., 808 Seventeenth St., N. W., Washington, D. C	Dec. 6, 1910
Tompkins, William Israel. Contr. Engr., Massillon Bridge & Structural Co., Massillon, Ohio	Jan. 2, 1912
Tooker, Francis Westervelt. With The Met. Life Ins. Co., on Mt. McGregor Sanitorium, Wilton, N. Y	Dec. 6, 1905
Toops, George Noble. Box 14, Scullin, Okla. (*Jun., April 5, 1910*)	Oct. 4, 1910
Torre, Alberto de la. Res. Engr., The Colombian National Ry., Ltd. (Ferrocarril de Girardot), Girardot, Colombia	Oct. 3, 1906
Torrey, James Eaton. 612 East 26th St., Paterson, N. J	May 3, 1905
Tozzer, Arthur Clarence. Supt. of Constr., Turner Constr. Co., 11 Broadway, New York City. (*Jun., April 4, 1905*)	Feb. 28, 1911
Tracy, Louis Downer. Civ. and Min. Engr., 245 Fourth Ave. (Res., 108 Lincoln Ave., Edgewood Park, Allegheny Co.), Pittsburgh, Pa	Oct. 3, 1906
N. Tratman, Edward Ernest Russell. 1138 Monadnock Blk., Chicago, Ill. (*Jun., April 7, 1886*)	July 1, 1891
Travell, Warren Bertram. With Hooper-Falkenau Eng. Co., 165 Broadway, New York City. (*Jun., April 30, 1895*)	Mar. 5, 1902
Treadway, Howard Platt. Vice-Pres. and Treas., Kansas City Bridge Co., 510 Orear-Leslie Bldg., Kansas City, Mo	May 6, 1903
Treadwell, William Adams. Asst. Engr., New York State Dept. of Highways, 187 Elk St., Albany, N. Y. (*Jun., April 4, 1905*)	Feb. 1, 1910
Trott, David Crooker. Supt. of Constr., U. S. Public Bldgs., Missoula, Mont	Sept. 6, 1910
Trow, Frank Hamant. Chf. Engr. for MacArthur Bros. Co. and Winston & Co., Contrs., Brown Station, N. Y	Feb. 7, 1906

	Date of Membership
True, Albert Otis. Asst. Engr., New York State Dept. of Health, Albany, N. Y. (*Jun., Feb. 5, 1907*)	May 31, 1910
Tucker, Herman Franklin. Res. Engr., Peter Bent Brigham Hospitals, 697 Huntington Ave., Boston (Res., 60 Greenough St., Brookline), Mass	Dec. 7, 1904
Tudbury, Warren Chamberlain. 47 West 126th St., New York City	June 1, 1909
Tudor, Clinton Gambrill. 1456 Monroe St., N. W., Washington, D. C.	May 1, 1907
Tull, Richard William. Asst. Engr., Eastern Steel Co., 60 Broadway, New York City	May 3, 1905
Tunstall, Whitmell Pugh. Board of Superv. Engrs., Chicago Traction, 181 La Salle St., Chicago, Ill. (*Jun., Oct. 6, 1903*)	Nov. 4, 1908
Turley, Omner Jay. Turley, N. Mex	April 6, 1909
Turneaure, Frederick Eugene. Dean, Coll. of Eng., Univ. of Wisconsin, Madison, Wis. (*Assoc., Aug. 31, 1897*)	June 4, 1902
Turner, Augustus Miesse. Res. Engr., The C., C., C. & St. L. Ry., Sharonville, Ohio	Dec. 1, 1908
Turner, Franklin Pierce. Asst. Engr., N. & W. Ry., Kenova, W. Va. (Res., Christiansburg, Va.)	May 6, 1908
Turner, George Dallas Baird. Cons. Engr., The South Cambria Collieries, Ltd., 98 Leadenhall St., London, E. C., England	Nov. 2, 1898
Turner, Henry Chandlee. Pres., Turner Constr. Co., 11 Broadway, New York City	April 4, 1906
Turner, John Patrick. Care, John J. Turner & Sons, 41 East Main St., Amsterdam, N. Y.	Feb. 28, 1911
Turner, Nathaniel Parker. Chf. Engr., Cuba R. R., Hotel Camaguey, Camaguey, Cuba	Dec. 1, 1908
Turney, Omar Asa. City Engr., Phœnix, Ariz	May 6, 1908
Twiggs, John David, Jr. Supt., Canal and Water-Works, Augusta, Ga.	Nov. 1, 1905
Tyler, Roy Dexter. 2607 Warren St., Cheyenne, Wyo	Mar. 6, 1907
Tyler, William Rogers. With Ruggles-Robinson Co., Contrs., 331 Madison Ave., New York City. (*Jun., Feb. 2, 1909*)	June 30, 1911
Tyrrell, Warren Ayres. 620 Chestnut St., St. Louis, Mo. (*Jun., Oct. 2, 1900*)	Oct. 1, 1902

Ulrich, Daniel. Katonah, Westchester Co., N. Y.	Sept. 1, 1897
Ulrich, Edmund Boyd. City Engr. and Chf. Commr. of Highways and Sewers, Reading, Pa	April 6, 1909
Underhill, Grandison Gridley. Asst. Engr., New York State Barge Canal, Albany, N. Y.	June 5, 1907
Underwood, Howard Warren. Engr. and Contr. (Field, Barker & Underwood, Inc.), 718 Arcade Bldg., Philadelphia, Pa. (*Jun., Dec. 3, 1901*).	April 3, 1907
Unger, Erik Birger Lund. P. O. Box 1086, Saskatoon, Sask., Canada	Nov. 8, 1909
Ungrich, Martin Jacob. Asst. Engr., Board of Water Supply, 127 Franklin St. (Res., 505 West 142d St.), New York City	Mar. 1, 1910
Upham, Richard Dana. 11 Broadway, New York City. (*Assoc., Oct. 6, 1896*)	April 3, 1901
Upson, Maxwell Mayhew. Secy., Gen. Mgr., and Chf. Engr., Raymond Concrete Pile Co., 140 Cedar St., New York City	May 6, 1908
Urquhart, George Copeland. Real Estate Agt., Penn. Lines W. of Pitts., 1104 Union Station Bldg., Pittsburgh, Pa	May 6, 1891

Vail, John Jervis. Constr. Dept., P. R. R. (Res., 59 Hazlewood Ave.), Rahway, N. J.	Jan. 4, 1905
Vallely, William Patrick. 410 West 148th St., New York City	Jan. 3, 1911
Valle Zeno, Carlos del. Contr. Engr. (Del Valle Zeno Bros.), San Juan, Porto Rico	April 1, 1908
Van Buskirk, Clarence Randall. Civ. Engr., Surv. and Archt., 180 Montague St., Brooklyn, N. Y.	Feb. 3, 1897
Vance, Alexander Milton. 609 New England Bldg., Topeka, Kans	Nov. 7, 1906
Van Duzer, William Albie. Party Chf., State Highway Dept., Franklin, Pa	June 30, 1911
Van Etten, Lawrence Edward. New Rochelle, N. Y.	Dec. 6, 1899
Van Hagan, Leslie Flanders. Asst. Prof., Ry. Eng., Univ. of Wisconsin, Room 304, Engineering Bldg., Madison, Wis.	June 6, 1911
Van Liew, John Edgar. Contr. Engr., Des Moines Bridge & Iron Works (Res., 1306 E. Grand Ave.), Des Moines, Iowa	July 1, 1908
Vanneman, Charles Reeve. Steam R. R. Insp., Public Service Comm., Second Dist. (Res., 436 Hudson Ave.), Albany, N. Y.	June 3, 1908
Van Ness, Howard Edward. Asst. Engr., C. R. R. of N. J., Little Falls, N. J.	Dec. 4, 1907
Van Ornum, Samuel Judson. City Engr., Pasadena, Cal	Dec. 4, 1907
Van Pelt, Sutton. Gen. Mgr. of Constr., Am. Asphaltum & Rubber Co., 601 Harvester Bldg., Chicago, Ill. (*Jun., Mar. 6, 1900*)	Dec. 2, 1903

	Date of Membership
Van Petten, Albert Alexander. With Porto Rico Constr. Co., Bayamon, Comerio Falls, Porto Rico	Dec. 5, 1911
van Reenen, Reenen Jacob. Engr., Irrig. Dept., Union of South Africa, P. O. Box 40, Cradock, Cape Province, South Africa	Oct. 3, 1911
Van Suetendael, Achille Octave. Structural Engr., State Archt.'s Office, Albany, N. Y. (*Jun., Jan. 3, 1905*)	June 3, 1908
Van Vleck, James Brackett. Supt., Fruin-Colnon Contr. Co., 6182 McPherson Ave., St. Louis, Mo. (*Jun., May 5, 1908*)	Jan. 2, 1912
Vedeler, Gerdt Henrik. Medlem av styret for det industrielle retsvern, Kronprinsens Gt. 4, Christiania, Norway	June 7, 1893
Vensano, Harry Chittenden. Engr., Pac. Gas & Elec. Co., 445 Sutter St., San Francisco, Cal. (*Jun., June 4, 1907*)	Dec. 5, 1911
Vernon, Stephen Barker. Asst. Engr., Syracuse Intercepting Sewer Board, City Hall, Syracuse, N. Y	Jan. 4, 1910
Verveer, Emanuel Louis. Contr. Engr., Alfred E. Norton Co., 18 West 27th St., New York City	June 3, 1903
Vickers, Thomas McElderry. Mgr., Waldorf Mfg. Co., Auburn, N. Y	Mar. 2, 1898
Vilar y Boy, Santiago. Asst. Engr., Guatemala Ry., Guatemala, Guatemala	Oct. 31, 1911
Villalon, José Ramon. Calle de Cuba No. 37, Havana, Cuba. (*Jun., July 4, 1888*)	Nov. 6, 1895
Vinton, Thomas MacIntire. Pres., Tucker & Vinton, Terminal Bldg., 41st St. and Park Ave., New York City	Feb. 3, 1904
Vliegenthart, Johannes Cornelis. Engr., Hai-ho River Conservancy, Tientsin, North China	June 5, 1907
Vogt, John Henry Leon. Const. Engr., R. F. D. No. 1, Box 170, San Diego, Cal	April 6, 1909
Volck, Adalbert George. With O'Rourke Eng. Constr. Co., 345 Fifth Ave. (Res., 456 Riverside Drive), New York City. (*Jun., Dec. 1, 1908*)	Dec. 5, 1911
von Unwerth, Hans. Cons. Engr., 722 Dwight Bldg., Kansas City, Mo.	May 6, 1903
Voorhees, Paul. Asst. Engr., P. & R. Ry., Room 508, Telegraph Bldg., Harrisburg, Pa	Feb. 3, 1892
Voynow, Constantine Borisson. Asst. Engr.-of-Way, Phil. Rap. Trans. Co., 820 Dauphin St., Philadelphia, Pa	Sept. 7, 1904
Vrooman, Morrell. City Engr., Gloversville, N. Y	May 7, 1902
Wachter, Charles Lucas. Engr., Lidgerwood Mfg. Co., 96 Liberty St., New York City. (*Jun., June 3, 1902*)	Oct. 5, 1904
Wada, Yoshichika. Shimamura, Sabagun, Gunbaken, Japan. (*Jun., Sept. 7, 1887*)	Oct. 2, 1895
Waddell, Frederick Creelman. Structural Engr. with Hudson Structural Steel Co., 136th St. and Southern Boulevard, New York City	Oct. 4, 1905
Wade, George Willis. Asst. Engr., S. P. Co., 3d and Townsend Sts., San Francisco, Cal	Nov. 1, 1910
Wadhams, Joseph Palmer. Asst. Engr., N. Y., N. H. & H. R. R., New Haven, Conn	Oct. 31, 1911
Wagner, Allan John. Engr., California Corrugated Culvert Co., West Berkeley, Cal	April 4, 1911
Wait, Bertrand Hinman. Div. Engr., Board of Water Supply, 700 West 181st St., New York City	Jan. 2, 1912
Wait, Owen Adelbert. Asst. Engr., Southern Cal. Edison Co., 329 San Fernando Bldg., Los Angeles, Cal	Dec. 6, 1905
Waite, Donald Cramer. Asst. Engr., Interborough Rapid Transit Co., 165 Broadway, New York City (Res., 1397 East 17th St., Brooklyn, N. Y.). (*Jun., Jan. 3, 1905*)	April 5, 1910
Waldron, Albert Edwin. Capt., Corps of Engrs., U. S. A., U. S. Engr. Office, P. O. Bldg., New London, Conn	July 1, 1909
Walker, Albert Willard. Asst. Engr., U. S. Reclamation Service, Orman, S. Dak	May 3, 1910
Walker, Edward Lloyd. Superv. Engr., Chf. Engr.'s Office, Dept. of Water Supply, Gas and Electricity, 21 Park Row, New York City. (*Jun., Feb. 3, 1903*)	Oct. 3, 1906
Walker, Edward Mansfield. With Grade Separation Dept., Mich. Cent. R. R. (Res., 190 Owen Ave.), Detroit, Mich	Nov. 8, 1909
Walker, George Johnson. Contr. Engr., Heyl & Patterson, Inc. (Res., 5433 Elmer St.), Pittsburgh, Pa. (*Jun., Dec. 6, 1904*)	Oct. 31, 1911
Walker, Joseph Jeanes. Dobbs Ferry, N. Y	Nov. 5, 1902
Wall, George Albert. Care, C. P. Ry., Irrig. Dept., Calgary, Alta., Canada	Jan. 3, 1911
Wallace, William McGehee. 2028 F St., N. W., Washington, D. C. (*Jun., April 3, 1894*)	Nov. 6, 1901
Walling, Victor Roy. Supt., Cananea Consolidated Copper Co.'s Ry., Cananea, Sonora, Mexico	June 6, 1906

	Date of Membership
Walsh, James Joseph. Asst. Engr. with Howard C. Holmes, 112 Market St., San Francisco, Cal.	Sept. 5, 1911
Walter, George Shirley. Care, Hotchkiss Contr. Co., 1210 Manhattan Bldg., Chicago, Ill.	Jan. 5, 1909
Walters, Henry Radclyffe St. Arvans. Fabricating Engr., Bethlehem Steel Co., South Bethlehem (Res., 228 Wall St., Bethlehem), Pa. *(Jun., Oct. 6, 1903)*	April 5, 1905
Walther, Edward. 1421 Humboldt Boulevard, Chicago, Ill.	May 1, 1895
Ward, Charles Clarence. Chf. Engr., Grant Realty Co., Moses Lake, Wash.	July 10, 1907
Ward, Walter. Parma, Idaho	May 3, 1910
Warfield, Ralph Mervine. Navy Yard, Bremerton, Wash.	Sept. 5, 1911
Waring, Charles Thomas. Div. Engr., Cape Cod Canal, Buzzards Bay, Mass.	Mar. 1, 1910
Warlow, Adoniram Judson. Bethlehem Steel Co., 313 West North St., Bethlehem, Pa. *(Jun., May 1, 1906)*	Dec. 6, 1910
Warner, John Elliott. County Surv. and Highway Engr., Scott County, Benton, Mo.	Sept. 6, 1910
Warren, Herbert Anson. Contr. Mgr., Am. Bridge Co. of N. Y., 600 Continental Trust Bldg., Baltimore, Md.	Sept. 5, 1906
Warren, Horace Prettyman. Care, J. S. Appleman, M. D., 4746 Prairie Ave., Chicago, Ill.	Jan. 3, 1911
Washington, William de Hertburne. 220 Fifth Ave., New York City	Oct. 5, 1892
Wasser, Thomas James. 1 Montgomery St., Jersey City, N. J.	April 3, 1907
Wassner, Michael. Locating Engr., National R. R. of Haiti, Cape Haitien, Haiti	June 5, 1907
Watanabe, Eitaro. Imperial Taiwan Rys., Takow, Formosa, Japan	April 5, 1905
Waterbury, Leslie Abram. Prof. of Civ. Eng., Univ. of Arizona, Tucson, Ariz. *(Assoc., Nov. 7, 1906)*	June 30, 1910
Watkins, Guy Anderson. (Dickinson & Watkins), State Bank Bldg., Little Rock, Ark. *(Jun., Jan. 3, 1907)*	Nov. 8, 1909
Watson, Walter. Lewisburg, Tenn.	April 5, 1893
Webber, Charles Perkins. Ingeniero Principal de Construccion, Ferro Carriles Nationales de Mexico, Apartado 11, Tierra Blanca, Ver., Mexico	Oct. 7, 1908
Webber, Roy Irvin. Associate Prof., Structural Eng., The Pennsylvania State Coll., State College, Pa.	April 1, 1908
Wedgeworth, Donald Clark. Res. Engr., Dept., State Engr. and Surv., Weighlock Bldg., Syracuse, N. Y.	April 1, 1908
Weeks, Harry Arthur. Barge Canal Office, Lyons Blk., Albany, N. Y.	April 4, 1911
Weidel, Joseph. Asst. Engr., A., T. & S. F. Ry. System, 704 Horne St., Topeka, Kans.	July 10, 1907
Weidner, Carl Robert. Instr. in Hydr. Eng., Univ. of Wisconsin, 422 North Henry St., Madison, Wis. *(Jun., Feb., 28, 1905)*	April 5, 1910
Weigmann, William Julius. Asst. Engr., New York State Barge Canal, 4 Elmer Ave., Schenectady, N. Y.	June 30, 1911
Weiland, Adelbert Alonzo. Chf. Engr. for The Arkansas Val. Ditch Assoc., 410 Central Blk., Pueblo, Colo.	April 6, 1909
Weinstock, Harry Herschel. Auditor, New York Times Co., 2400 Seventh Ave., New York City	June 30, 1910
Weiss, Andrew. Project Engr., U. S. Reclamation Service, Mitchell, Nebr.	Jan. 8, 1908
Welborn, Marvin Curtis. Engr., Water, Light and Power Dept., City of Austin, Austin, Tex.	Nov. 8, 1909
Weller, Francis Repetti. Civ. and Hydr. Engr., Hibbs Bldg., Washington, D. C. *(Jun., Feb. 5, 1901)*	Nov. 1, 1905
Weller, William Earl. Deputy City Engr., 63 Robinson St., Schenectady, N. Y. *(Jun., Jan. 7, 1908)*	Oct. 3, 1911
Welton, Benjamin Franklin. Examining Engr., Commrs. of Accounts, 280 Broadway, New York City (Res., 1 Wiener Pl., Tompkinsville, N. Y.). *(Jun., April 6, 1897)*	Nov. 1, 1905
Wemlinger, Julius Ralph. Pres., Wemlinger Steel Piling Co., 11 Broadway, New York City	Nov. 8, 1909
Wenige, Arthur Emil. Asst. Engr., Dept. of Water Supply, Borough of Brooklyn, Brooklyn, N. Y. *(Jun., May 6, 1902)*	Oct. 7, 1908
Werbin, Israel Vernon. 70 East 45th St., Room 2045, New York City	April 4, 1911
Wescott, Jay Varnum. Q. & C. Co., Peoples Gas Bldg., Chicago, Ill.	Nov. 30, 1909
West, Oscar James. Mgr., Am. Concrete Pile & Pipe Co., 449 The Rookery, Chicago, Ill.	May 4, 1904
Weston, Frederick Sampson. Asst. Engr., Madeira-Mamoré Ry., Porto Velho, Brazil. *(Jun., Oct. 5, 1909)*	June 6, 1911
Westover, Henry Christopher. 424 Rialto Bldg., Kansas City, Mo. *(Jun., Nov. 1, 1904)*	April 5, 1910
Wheat, George Neville. Structural Engr., Kansas City Terminal Ry., Kansas City, Mo.	Jan. 4, 1910
Wheaton, Walter Robert. Supt. of Timber Dept., San Joaquin Light & Power Co., Fresno, Cal.	Feb. 2, 1909

	Date of Membership
Wheeler, Arthur Chambers. Asst. Supt., Bureau of Public Works, Honolulu, Hawaii	Oct. 7, 1908
Wheeler, Ralph Norman. Div. Engr., New York Board of Water Supply, 236 Main St., Poughkeepsie, N. Y.	Jan. 7, 1903
Whipple, Robert Lee. Contr. and Engr., 306 Main St., Worcester, Mass.	Sept. 6, 1910
Whiskeman, James Peter. Cons. Engr., 39 West 38th St., New York City. *(Jun., Jan. 31, 1899)*	Nov. 7, 1900
Whitaker, Ralph Wallace. Obras del Puerto No. 2, Vera Cruz, Mexico	April 5, 1910
Whitaker, William Franklin. Supt. of Canals, Kern County Canal & Water Co., 2620 Nineteenth St., Bakersfield, Cal. *(Jun., April 4, 1905)*.	Sept. 6, 1910
Whitbeck, Lee Field. Prin. Engr., National Rys. of Mexico, Estacion Pénjamo, Guanajuato, Mexico. *(Jun., Dec. 6, 1904)*	Nov. 1, 1910
White, Arthur Burr. Civ. and Hydr. Engr. (Bixby & White), 502 Mason Bldg., Los Angeles, Cal.	Nov. 7, 1906
White, Byron Ellsworth. Engr., Utica Gas & Elec. Co., 222 Genesee St. (Res., 15 Steuben St.), Utica, N. Y. *(Jun., Oct. 2, 1906)*	July 1, 1908
White, David Miller. Vice-Pres. and Chf. Engr., Victor Irrig. Co., Midland, Tex.	Nov. 8, 1909
White, Frank George. Asst. Engr., Board of State Harbor Commrs., San Francisco, Cal. *(Jun., Dec. 3, 1901)*	Dec. 7, 1904
White, Gilbert Case. Cons. Engr., Durham, N. C.	April 5, 1905
White, Lazarus. Div. Engr., Board of Water Supply, 250 West 54th St., New York City. *(Jun., May 1, 1900)*	Feb. 4, 1903
Whitford, Noble Earl. Res. Engr., Dept. of State Engr., State Hall, Albany, N. Y.	Feb. 1, 1905
Whiting, George William Carlyle. Pres., The Whiting-Turner Constr. Co., Sexton Bldg., Baltimore, Md. *(Jun., Sept. 5, 1905)*	Nov. 8, 1909
Whitman, Nathan Davis. Engr., Reinforced Concrete Pipe Co., 525 Central Bldg., Los Angeles, Cal.	Dec. 5, 1906
Whitman, Ralph. Asst. Civ. Engr., U. S. N., U. S. Naval Station, Guantanamo, Cuba (*via* Postmaster, New York)	Nov. 6, 1907
Whitney, Harrison Allen. 1213 Wilcox Bldg., Portland, Ore.	Jan. 3, 1911
Whitsit, Lyle Antrim. Prin. Asst. Engr., Long Sault Development Co. and St. Lawrence River Power Co., Massena, N. Y. *(Jun., Oct. 31, 1905)*	Sept. 6, 1910
Whitson, Abraham Underhill. Asst. Engr., Board of Water Supply, Cold Spring, N. Y. *(Jun., Jan. 7, 1902)*	Dec. 5, 1906
Whitted, Levi Romulus. Supt. of Constr., U. S. Public Bldgs., Treasury Dept., Burlington, N. C. *(Jun., Mar. 6, 1900)*	July 9, 1906
Whittet, Rufus Mason. Asst. Engr., Massachusetts State Board of Health, 141 State House, Boston, Mass.	May 2, 1911
Wickersham, John Hough. Lancaster, Pa. *(Jun., May 6, 1902)*	April 6, 1909
Wickes, Joseph Lee. Engr., U. S. Fidelity & Guaranty Co., Home Office, Baltimore, Md.	Mar. 2, 1904
Wickham, Harry Rogers. Asst. Engr., Dept., State Engr. and Surv., in Chg. Contract No. 23, 69 South Goodman St., Rochester, N. Y.	June 6, 1911
Widdicombe, Robert Alexander. Care, W. A. Pope Co., 5552 Lakewood Ave., Chicago, Ill. *(Jun., April 2, 1901)*	Dec. 6, 1905
Wiggin, Ernest Woodbury. Engr., Central New England Ry., Hartford (Res., 48 Third St., New Haven), Conn. *(Jun., May 5, 1896)*	May 7, 1902
Wiggin, Thomas Hollis. Senior Designing Engr., Board of Water Supply, 165 Broadway, New York City	April 2, 1902
Wiggins, Ralph Raymond. 233 College Ave., Houghton, Mich.	Oct. 5, 1909
Wiggins, William D. Engr., M. of W., Pittsburgh Div., P., C., C. & St. L. Ry., 1013 Penn Ave., Pittsburgh, Pa.	Oct. 2, 1901
Wilbanks, John Robert. 630 Southern Trust Bldg., Little Rock, Ark. *(Jun., June 4, 1907)*	Sept. 5, 1911
Wilcock, Frederick. Asst. Engr., Public Service Comm., New York City, 23 Flatbush Ave., Brooklyn, N. Y. *(Jun., Jan. 7, 1902; Assoc., Oct. 6, 1903)*	Jan. 4, 1910
Wilcox, Clark Luzerne. Treas., The Pitt Constr. Co., Inc., 821 Fulton Bldg., Pittsburgh, Pa. *(Jun., Dec. 3, 1901)*	Mar. 1, 1910
Wilcox, Frank Leslie. Cons. Engr., Chemical Bldg., St. Louis, Mo. *(Jun., Sept. 6, 1904)*	Feb. 1, 1910
Wilcox, Fred Elmer. 956 Orange Grove Boulevard, Pasadena, Cal.	April 1, 1896
C. Wild, Herbert Joseph. Care, N. T. Wilcox, 23 Burtt St., Lowell, Mass. *(Jun., Mar. 31, 1903)*	April 6, 1904
Wilder, Clifton White. Elec. Engr., Public Service Comm., First Dist., State of New York, 406 East 21st St., Brooklyn, N. Y.	Oct. 3, 1911
Wildes, Waldo Gilman. Res. Engr., Barge Canal Office, Albany, N. Y. *(Jun., Feb. 3, 1903)*	Jan. 2, 1907
Wilhelm, George. Chf. Engr., Peoples Water Co., Oakland, Cal.	Oct. 4, 1910
Wilhelm, Jerome Frederick. 903 South 2d St., St. Louis, Mo. *(Jun., Jan. 2, 1900)*	Mar. 7, 1906
Willard, Norman Rand. Superv. Engr., Porto Rico Irrig. Service, Guayabal Dam, Juana Diaz, Porto Rico	June 1, 1909

	Date of Membership
Williams, Enrique Ruiz. Locating Engr., Cuban Central Rys., Ltd., Sagua la Grande, Cuba	Dec. 6, 1910
Williams, Harold S. Caldwell, Idaho. (*Jun., Sept. 1, 1908*)	April 5, 1910
Williams, Jacob Paul Jones. Asst. Prof. of Civ. Eng., Columbia Univ., New York City	July 1, 1909
Williams, James Henry. Supt. of Dam and Water Supply Work, Fort Meade, S. Dak	June 6, 1911
Williams, LeRoy Duncan. County Surv. and Highway Engr., Macon County, Macon, Mo. (*Jun., Feb. 5, 1907*)	May 31, 1910
Williams, Lester Dennison. Secy. and Treas., Federal Eng. Co., 218 Stephenson Bldg., Milwaukee, Wis	Nov. 8, 1909
Williams, Maurice. Asst. Engr., New York State Barge Canal, Contract 29, Frankfort, N. Y	Jan. 31, 1911
Williams, Parley Lycurgus, Jr. Care, Daly West Min. Co., 163 Main St., Salt Lake City, Utah	Sept. 7, 1904
Williams, Roger Butler, Jr. Care, The Susquehanna Ry., Light & Power Co., 40 Wall St., New York City. (*Jun., Oct. 1, 1901*)	Mar. 7, 1906
Williams, Samuel Walter. 1035 Security Bldg., Los Angeles, Cal	Feb. 7, 1906
Williams, Walter Scott. Asst. Prof., Civ. Eng., Univ. of Missouri, 818 Virginia Ave., Columbia, Mo	April 6, 1904
Williamson, Harry. Sectional Engr., Buenos Aires & Pacific Ry., Ltd., Bahia Blanca, Argentine Republic	Oct. 4, 1910
Willis, Harry Parsons. Div. Engr., Dept. of Highways, Albany, N. Y.	Mar. 6, 1907
Wills, Arthur John. 2561 Mance St., Montreal, Que., Canada	May 7, 1902
Wilson, Edbert Carson. Engr., Lockwood Co., 139 Main St., Waterville, Me	Feb. 6, 1912
Wilson, Hanson Zimri. Engr., Constr. Dept., Standard Oil Co., 26 Broadway, New York City	June 30, 1911
Wilson, Harry Percival. 11 Shirley St., Worcester, Mass. (*Jun., Nov. 5, 1907*)	Oct. 5, 1909
Wilson, James Bean. Res. Bridge Engr., New Ohio River Bridge, 29th and High Sts., Louisville, Ky	May 2, 1906
Wilson, Phillip Lindsley. Div. Engr., F. E. C. Ry., Key West Extension, Islamorada, Fla	July 1, 1908
Wilson, Robert Brown Murphy. Asst. Supt., Sinaloa Div., F. C. S. P. de M., Mazatlan, Sinaloa, Mexico	June 30, 1911
Wilson, Thad Loren. Asst. Engr., Sewer Div., Rapid Transit Comm., Brooklyn, N. Y. (Res., 1082 Simpson St., New York City)	July 10, 1907
Wilson, Thomas William. Gen. Mgr., International Ry., 808 Ellicott Sq. (Res., 548 Franklin St.), Buffalo, N. Y	April 4, 1900
Wilson, Wilbur Thomas. 520 West 122d St., New York City	July 1, 1908
Wilson, William. Architectural Engr. with Grosvenor Atterbury, 20 West 43d St., New York City	Feb. 6, 1912
Wilson, William Renfrew. Imperial Rys. of North China, Tientsin, North China	Jan. 4, 1910
Winchester, Philip Harold. Div. Engr., N. Y. C. & H. R. R. R., Watertown, N. Y. (*Jun., Jan. 7, 1902*)	Feb. 5, 1908
Winfree, Peyton Brown. Asst. Mgr., The Glamorgan Pipe & Foundry Co., Lynchburg, Va. (*Jun., Oct. 2, 1894*)	May 3, 1898
Wing, Frederick Kelly. Cons. Engr., 910 White Bldg., Buffalo, N. Y. (*Jun., May 31, 1892*)	Nov. 1, 1899
Winn, Walter Scott. 321 James Bldg., Chattanooga, Tenn	Oct. 6, 1897
Winslow, Arthur Ellsworth. Prof., Civ. Eng., Norwich Univ., Northfield, Vt	June 6, 1906
Winslow, Carlile Patterson. In Chg., Co-operative Projects, Forest Products Laboratory, Madison, Wis	Mar. 1, 1910
Winterhalter, Leo P. 70 N. Prospect St., Akron, Ohio	July 1, 1909
Wise, James Hugh. Asst. Gen. Mgr., Pacific Gas & Elec. Co., 445 Sutter St., San Francisco, Cal.	Feb. 6, 1907
Wise, Robert Emmet. Asst. Engr., New York City Dept. of Water Supply, Gas and Electricity, 523 West 122d St., New York City	May 2, 1911
Witham, Myron Ellis. Cons. Engr. (Bull & Witham), 1015 Foster Bldg., Denver, Colo	Aug. 31, 1909
Witt, Jackson Franklin. County Engr., Dallas County, Dallas, Tex.	Oct. 31, 1911
Wolcott, Christopher Stanton. Contr. (Wolcott & Conroy), 284 Main St., Hornell, N. Y	June 5, 1907
Wonson, Samuel Lamson. Gen. Bridge Insp., Mo. Pac. Ry., 809 Mo. Pac. Bldg., St. Louis, Mo	Oct. 5, 1909
Wood, George. 122 West 167th St., High Bridge, New York City	June 5, 1907
Wood, George Roy. Elec. Dept., Berwind-White Coal Min. Co., Arcade Bldg., Philadelphia, Pa	April 4, 1906
Wood, Robert Walter. Asst. Engr. in Chg. of Port Richmond Div., Borough of Richmond, New York City, 913 Post Ave., Port Richmond, N. Y. (*Jun., April 30, 1907*)	Nov. 8, 1909
Wood, Winthrop Barrett. Civ. and Mech. Engr. for The Wanskuck Co., 725 Branch Ave., Providence, R. I	April 6, 1904

	Date of Membership
Woodard, Wilkie. 741 Consolidated Realty Bldg., Los Angeles, Cal	May 4, 1904
Woodcock, Henry Wright. Civ. Engr. and Surv., 261 Fifty-second St., Brooklyn, N. Y. (*Jun., Dec. 1, 1903*)	Dec. 4, 1907
Woodle, Allan Sheldon, Jr. Baldwin Locomotive Works, Philadelphia, Pa.	July 9, 1906
Woods, Andrew Alfred. Res. Engr., Alabama & Vicksburg Ry. and Vicksburg, Shreveport & Pacific Ry., Vicksburg, Miss	May 4, 1904
Woodward, Edwin Carlton. Paving Engr., 1400 Cooper St., Fort Worth, Tex	Oct. 4, 1905
Woodward, Frank Coy. East Pepperell, Mass	June 30, 1911
Work, Joe Young. Care, Elks Club, Denver, Colo	May 3, 1910
Worley, Albert Harrison. With Hedrick & Cochrane, 1118 McGee St., Kansas City, Mo	Oct. 31, 1911
Worley, John Stephen. 206 Reliance Bldg., Kansas City, Mo	June 5, 1907
Wortendyke, Nicholas Doremus. Asst. Chf. Engr., Board of Street and Water Commrs., City Hall (Res., 108 Bentley Ave.), Jersey City, N. J	Feb. 1, 1899
Wortham, John Root. 225 Coronado Blk., Greeley, Colo. (*Jun., Oct. 31, 1905*)	Oct. 7, 1908
Wright, Otis Hord. Asst. Engr., Water Dept., Portland, Ore	May 2, 1911
Wrigley, Harry Blakemore. Mech. Engr., Dodge Mfg. Co., 815 Arch St., Philadelphia, Pa	Nov. 6, 1907
Wyckoff, Charles Rapelyea. Asst. Engr., Board of Water Supply, City of New York, Realty Bldg., White Plains (Res., 185 Penn St., Brooklyn), N. Y. (*Jun., May 5, 1903*)	Sept. 5, 1911
Wyman, Alfred Marshall. Asst. Engr., Public Service Comm., First Dist., 154 Nassau St., Room 2012, New York City. (*Jun., Jan. 2, 1906*)	Mar. 2, 1909
Wynn, Wesley Akers. Dist. Engr., Pennsylvania State Highway Dept., Warren, Pa	April 4, 1911
Yappen, Adolph. Dist. Carpenter, C., M. & St. P. Ry., Cor. Grand and North California Ave., Chicago, Ill	June 1, 1909
Yates, Bruce Clinton. Asst. Chf. Engr., Homestake Min. Co., Lead, S. Dak	June 7, 1905
Yates, Eugene Adams. Supt., MacArthur Bros. Co., 644 Brown Marx Bldg., Birmingham, Ala. (*Jun., Oct. 3, 1905*)	Oct. 2, 1907
Yates, Joseph Johnson. Bridge Engr., C. R. R. of N. J., 143 Liberty St., New York City	May 2, 1906
Yates, William Henry. Superv. Engr., Barge Canal, Barge Canal Office, Albany, N. Y. (*Jun., Feb. 2, 1904*)	Jan. 8, 1908
Yen, Te Ching. Asst. Chf. Engr., Szechuen Chuenhan Ry., Ichang, China. (*Jun., Dec. 1, 1903*)	April 1, 1908
Yeo, William Herbert Watt. Elephant Butte, N. Mex	Feb. 1, 1910
Young, Alexander Ririe. City Engr., 1311 Clay St., Topeka, Kans	Sept. 5, 1911
Young, Charles Newton. 780 Joost Ave., San Francisco, Cal	Feb. 2, 1909
Young, Henry Amerman. (Young & Hyde), Produce Exchange Bldg., New York City (Res., 18 Belmont Ave., Yonkers, N. Y.). (*Jun., Mar. 5, 1901*)	Dec. 2, 1903
Young, Lewis Maxwell. Norwich, Conn	April 6, 1909
Zabriskie, Albert Menger. Asst. Engr., C. R. R. of N. J., 143 Liberty St., New York City	Dec. 4, 1907
Zachry, John Low. City Engr. and Director of Public Works, Brunswick, Ga	Nov. 7, 1906
Zimmermann, Walter Gustaf. Contr. Mgr., Am. Bridge Co. of N. Y., Sherwood Bldg., Duluth, Minn	Oct. 7, 1908
Zipser, Morris Ernest. Asst. Engr., Board of Water Supply, City of New York, 236 Main St., Poughkeepsie, N. Y	Oct. 31, 1911
Zorn, George Washington. Hydr. and Gen. Eng., Germania, Wyo	Dec. 7, 1904

Associate Members, 2 424.

ASSOCIATES

[Assoc. Am. Soc. C. E.]

	Date of Membership
Ackerman, Ernest Robinson. 1 Broadway, New York City	May 1, 1900
Ambler, Daniel Griffith. Litchfield, Conn	Mar. 7, 1906
Anderson, Robert. Vice-Pres., The Ferro-Concrete Constr. Co., 2461 Grandin Rd., Cincinnati, Ohio	Nov. 6, 1907
Atwell, Harry Hurd. 2305 Geddes Ave., Ann Arbor, Mich. (*Jun., Mar. 31, 1908*)	Jan. 4, 1910
Auchincloss, John Winthrop. 22 William St., New York City	April 2, 1901
Belden, Edgar Tweedy. Sales Mgr., Farnum Cheshire Lime Co., Pittsfield Lime Co., 215 Dawes Ave., Pittsfield, Mass	Mar. 5, 1901
Belknap, Robert Ernest. Chicago Sales Agt., The Pennsylvania Steel Co., Maryland Steel Co., 1007 McCormick Bldg., Chicago, Ill	Jan. 3, 1911
Belzner, Theodore. Bridge Insp. (Maintenance); Insp., Steel Constr., Williamsburgh Bridge, Dept. of Bridges, City of New York, 84 Broadway, Brooklyn, N. Y. (Res., 614 West 135th St., New York City). (*Jun., Oct. 5, 1897*)	May 3, 1910
Bennett, Leslie J. Secy., Buffalo Cement Co., 110 Franklin St., Buffalo, N. Y	Jan. 7, 1902
Bent, Stedman. Overbrook, Pa	Dec. 2, 1902
Bernegau, Rudolf Caspar Carl Marie. 127 Fulton St., New York City	Feb. 3, 1903
Bogart, Samuel Stockton. 15 Broad St., New York City	April 7, 1886
Bouton, Harold. Counsellor at Law and Cons. Engr., 2 Rector St., New York City. (*Jun., May 2, 1899*)	Mar. 7, 1906
Bradley, Charles Whiting. C. & O. Ry., Richmond, Va	June 19, 1891
Braine, Lawrence Fulton. Vice-Pres., The Rail Joint Co., 185 Madison Ave., New York City	Sept. 6, 1898
Bromley, Albert Henry, Jr. Concrete Engr., Care, Guarantee Constr. Co., 140 Cedar St., New York City	Feb. 2, 1909
Brooks, David Walker. Clinton Bldg., Columbus, Ohio	Dec. 5, 1906
Brown, John Griffiths. Contr. Engr., Witherspoon Bldg., Philadelphia, Pa	July 9, 1906
Brown, Joseph Henry, Jr. Mech. Engr. with Sullivan Machinery Co. of Chicago, 30 Church St., New York City	June 30, 1910
Brown, Thane Ross. With Wisconsin Bridge & Iron Co., North Milwaukee, Wis. (*Jun., Mar. 31, 1896*)	Oct. 2, 1900
Brown, William Alden. Mgr., Burham Works, Associated Portland Cement Mfrs. (1900), Ltd., Lloyds Ave., London, E. C., England	May 2, 1911
Bruce, John Moffatt. Care, General Motors Truck Co., Elec. Div., 236 West 59th St., New York City (Res., 582 Palisade Ave., Yonkers, N. Y.)	Jan. 3, 1906
Burnham, George, Jr. Director, Baldwin Locomotive Works, 1218 Chestnut St., Philadelphia, Pa. (*Jun., Jan. 6, 1875*)	July 2, 1890
Burrows, George Lord. Saginaw, W. S., Mich	Feb. 3, 1886
Caird, James Morton. Chemist and Bacteriologist, 271 River St., Troy, N. Y	Oct. 5, 1904
Chapman, Mellville Douglas. Broker, 80 Broadway, New York City	Sept. 1, 1896
Chaussé, Alcide. City Archt. and Supt. of Bldgs., P. O. Box 259, Montreal, Que., Canada	April 6, 1904
Christian, Charles Meriwether. 119 South Hamilton St., Poughkeepsie, N. Y	Nov. 1, 1910
Church, Irving Porter. Prof. of Applied Mechanics and Hydraulics, Cornell Univ., Ithaca, N. Y	Oct. 1, 1901
Clark, Ludlow Victor. 619 Harrison Bldg., Philadelphia, Pa	Oct. 4, 1892
Codwise, Henry Rogers. Asst. Prof. of Civ. Eng., Polytechnic Inst. of Brooklyn, Brooklyn, N. Y. (*Jun., April 2, 1901*)	April 6, 1909
Colby, Safford Kinkead. Treas., Pierson, Roeding & Co., 409 Monadnock Bldg., San Francisco, Cal. (*Jun., Mar. 5, 1895*)	Jan. 6, 1904
Cole, George Nathan. Eastern Representative, Cross Horizontal Folding & Warehouse Door Co., 1328 Broadway, New York City	Oct. 2, 1907

	Date of Membership
Colsten, Albert Lloyd. Cons. Engr., 1556 Seventy-third St., Brooklyn, N. Y.	Sept. 3, 1901
Compton, Alfred G. Prof. of Physics, The Coll. of the City of New York, Convent Ave. and 139th St. (Res., 40 West 126th St.), New York City.	Sept. 5, 1877
Conard, William Roberts. Inspections and Tests of Materials, Room 5, Savings Institution Bldg., Burlington, N. J.	Jan. 3, 1906
Connor, Edward James. Care, Spearin & Preston, 90 West St., New York City	Jan. 31, 1911
Constance, Edward Cartwright. Surv., U. S. Engr. Office, 428 Custom House, Box 71, St. Louis, Mo. (*Jun., Dec. 6, 1904*)	Feb. 6, 1907
Copeland, William Rogers. Care, Met. Sewerage Comm., 17 Battery Pl., New York City	Feb. 4, 1902
Corbaley, Charles William. 719 H. W. Hellman Bldg., Los Angeles, Cal.	Feb. 28, 1911
County, Albert John. Asst. to First Vice-Pres., P. R. R., 225 Broad St. Station, Philadelphia, Pa.	Aug. 31, 1909
Cuntz, William Cooper. Gen. Mgr. and Treas., Goldschmidt Thermit Co., 90 West St., New York City	Sept. 6, 1910
Currey, Jesse Albert. 1106 Wilcox Bldg., Portland, Ore.	Feb. 1, 1910
Currier, Charles Gilman. 313 West 102d St., New York City	June 21, 1894
Cushman, Allerton Seward. Director, Inst. of Industrial Research, 19th and B Sts., N. W., Washington, D. C.	Nov. 8, 1909
Dailey, John Alexander. 260 Glenwood Ave., East Orange, N. J.	Sept. 7, 1904
Denio, George La Pierre. 15 East Dayton St., Ridgewood, N. J.	July 9, 1906
Dewey, Charles Ellis. 46 Bank Bldg., Watertown, N. Y.	Nov. 5, 1901
de Wyrall, Cyril. Chf. Insp., Interborough Rap. Trans. Co., Subway Div., New York City	Feb. 6, 1907
Dilworth, Edward Coe. 5806 Howe St., Pittsburgh, Pa.	June 6, 1911
Diven, John M. Secy., Am. Water-Works Assoc., 271 River St., Troy, N. Y.	Sept. 10, 1891
Douglass, Anthony Chileon. Mayor, Niagara Falls, N. Y.	April 30, 1895
Drummond, Thomas Joseph. Pres., Lake Superior Corporation, Montreal, Que., Canada	Mar. 6. 1894
Eckel, Edwin Clarence. Cons. Engr. and Geologist, 725 Munsey Bldg., Washington, D. C.	Mar. 5, 1901
Eglee, Charles Henry. Gen. Mgr., Ambursen Hydr. Constr. Co., 176 Federal St., Boston, Mass.	July 10, 1907
Elliott, Howard. Pres., N. P. Ry., St. Paul, Minn.	June 5, 1900
Farrell, Edward James. 159 West 125th St., New York City	June 6, 1899
Ferris, James Joseph. Supt., F. M. Stillman Co., Gen. Contrs., 26 Exchange Pl., Jersey City, N. J.	July 10, 1907
Fisk, Wilbur Chapman. 30 Church St., New York City	Oct. 4, 1892
Foster, Clarence Marvin. Secy., Meacham & Wright Co., 805 Corn Exchange Bank Bldg., Chicago, Ill.	Jan. 31, 1899
Frost, George Henry. 745 Watchung Ave., Plainfield, N. J.	Jan. 4, 1882
Futami, Kyosaburo. Prof. of Civ. Eng., Kyoto Imperial Univ., Kyoto, Japan	June 5, 1889
Gaines, Franklin Lincoln. 236 So. Fuller St., Grand Rapids, Mich.	April 1, 1902
Gildersleeve, Alger Crocheron. 215 West 125th St., New York City. (*Jun., Feb. 6, 1894*)	April 4, 1899
Gilmore, Alvin Leroy. Binghamton, N. Y. (*Jun., April 6, 1909*)	Oct. 4, 1910
Goad, Charles Ernest. 15 Wellington St., West, Toronto, Ont., Canada.	April 4, 1911
Goldsborough, John Byron. Gen. Mgr., Jules Breuchaud Constr. Co., 290 Broadway, New York City	April 4, 1899
Goodell, John Milton. Editor, *Engineering Record*, 239 West 39th St., New York City	July 29, 1891
Goss, Oliver Perry Morton. Engr. in Timber Tests, Box 112, University Station, Seattle, Wash.	Feb. 28, 1911
Graham, William Woodman. Care, E. Stahlknecht & Co., Durango, Mexico.	Dec. 6, 1898
Graves, Edward Michael. 17 Commercial Bank Bldg., Cleveland, Ohio	Mar. 2, 1909
Green, Frederick William. Gen. Mgr., L. & A. Ry., Stamps, Ark.	May 1, 1907
Green, Howard Burkhardt. Sales Agt., Lehigh Portland Cement Co., 1218 Pennsylvania Bldg., Philadelphia, Pa.	Mar. 4, 1908
Gunther, Charles Otto. Prof. and Head of Dept. of Math., Stevens Inst. of Technology, Hoboken, N. J.	Sept. 6, 1910
Hardwicke, Alan Hyde Gardner. Gluck Bldg., Niagara Falls, N. Y.	June 4, 1884
Harrison, Louis Baldwin. Cons. and Contr. Engr., 220 Broadway, New York City	May 5, 1896

ASSOCIATES H-M

	Date of Membership
Hartmann, Ernest Frederick. Pres., Carbolineum Wood Preserving Co., 182 Franklin St., New York City	Jan. 4, 1910
Hartranft, William Garrigues. Pres., Wm. G. Hartranft Cement Co., Real Estate Trust Bldg., Broad and Chestnut Sts., Philadelphia, Pa.	May 3, 1898
Haupt, Edward. Secy., Strobel Steel Constr. Co., 1744 Monadnock Blk., Chicago, Ill.	Jan. 31, 1911
Hays, John Coffee. Visalia, Cal.	May 4, 1909
Hayward, Harrison Washburn. Asst. Prof., Applied Mechanics, Mass. Inst. Tech., Boston, Mass.	June 6, 1906
Healy, John Robert. 430 West 118th St., New York City	Jan. 8, 1908
Howe, James Vance. Res. Engr., Sandy Val. & Elkhorn Ry., Jenkins, Ky.	Nov. 30, 1909
Hughes, Harold Lincoln. Sales Mgr. and Res. Engr., United States Steel Products Export Co., G. P. O. Box 384, Sydney, New South Wales, Australia	April 1, 1908
Hunt, Carlton Eugene. With Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City	Oct. 3, 1906
Jacoby, Henry Sylvester. Prof. of Bridge Eng., Cornell Univ., 7 Reservoir Ave., Ithaca, N. Y.	Nov. 5, 1890
Johnson, Arthur Augustine. Sanford Ave. and 21st St., Flushing, N. Y.	Sept. 2, 1908
Jordan, Harry Edward. Supt., Filtration Dept., Indianapolis Water Co., 113 Monument Pl., Indianapolis, Ind.	Aug. 31, 1909
Kaltenbach, Henry Julius. Park Hill, Yonkers, N. Y.	June 3, 1902
Karner, William Josiah. Secy. and Treas., Bowne & Co., Inc., 81 Beaver St., New York City	July 2, 1890
Keller, Otto Balthazar. Eng. and Govt. Representative of Keuffel & Esser Co., 127 Fulton St., New York City	Feb. 3, 1903
Kenyon, William John Charles. Cons. Engr., 1625 Old Colony Bldg., Chicago, Ill.	May 31, 1910
King, Harry Wheelock. Vice-Pres., The King Bridge Co., Cleveland, Ohio	June 19, 1891
King, Wallace, Jr. Vice-Pres., United Bldg. Material Co., 30 Church St., Room 1012, New York City	Dec. 4, 1900
Kornfeld, Alfred Ephraim. Vice-Pres., *Engineering News*, 505 Pearl St., New York City	Oct. 7, 1908
Lally, John Michael. Supt. of Constr., Elec. Zone Impvts., N. Y. C. & H. R. R. R., 63 Dock St., Yonkers, N. Y.	Sept. 2, 1908
Lesley, Robert Whitman. Pres., Am. Cement Co., 604 Pennsylvania Bldg., Philadelphia, Pa.	Jan. 31, 1893
Liebmann, Alfred. 57 West 58th St., New York City	June 3, 1902
Lober, John Baptiste. 1230 Land Title Bldg., Philadelphia, Pa.	July 9, 1906
Lundberg, John Hervid. 80 Wall St., New York City	April 3, 1907
MacGregor, John. Engr., The United States Fidelity & Guaranty Co. of Baltimore, 126 No. Ashland St., Buffalo, N. Y.	June 2, 1903
McBurney, Henry. 520 Park Ave., New York City. (*Jun., Jan. 5, 1904*).	Nov. 6, 1907
McIntire, Thomas Burton. 52 Vernon Pl., Sherwood Park, Yonkers, N. Y. (*Jun., Mar. 1, 1904*)	Oct. 3, 1906
McKenna, Charles Francis. Chemist, 221 Pearl St., New York City	June 5, 1894
Maignen, Jean Prosper Auguste. Filtration Engr., 52 North 13th St., Philadelphia, Pa.	Oct. 3, 1899
Marsh, Albert Lereaux. With Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City (Res., 282 Montclair Ave., Newark, N. J.).	Oct. 3, 1911
Meriwether, Coleman. Pres. and Chf. Engr., Lock Joint Pipe Co., 165 Broadway, New York City	Feb. 7, 1906
Meyer, Henry Coddington, Jr. Cons. Mech. Engr., 1 Madison Ave., New York City (Res., Montclair, N. J.). (*Jun., Jan. 3, 1893*)	Dec. 28, 1900
Miller, John William. Instr., Ry. Eng., Univ. of Washington, 5517 Twelfth Ave., N. E., Seattle, Wash.	April 4, 1911
Monahan, John Joseph. Builder, West Chelmsford, Mass.	June 1, 1904
Monks, John, Jr. 82 Beaver St., New York City	May 31, 1898
Moran, Robert Breck. 519 California St., San Francisco, Cal. (*Jun., Sept. 1, 1908*)	June 6, 1911
Morris, Davis Harrington. Special Agt., Central Union Telephone Co., Dayton, Ohio	Nov. 6, 1907
Moxham, Arthur James. Room 926, du Pont Bldg., Wilmington, Del.	Nov. 2, 1887
Moyer, Albert. 200 Fifth Ave., New York City	Feb. 7, 1906

	Date of Membership
Newton, James Dynan. Dean, Coll. of Eng. of Loyola Univ., 1307 Columbia Ave., Rogers Park, Chicago, Ill	Sept. 5, 1911
Oastler, William Churchill. 200 West 56th St., New York City	Mar. 31, 1891
Odell, Rutledge Irving. Vice-Pres., The Tomkins Cove Stone Co., Tomkins Cove, N. Y	Oct. 1, 1895
Olds, William Clarence. Erie, Pa	Nov. 3, 1903
Packard, Ralph Gooding, Jr. Vice-Pres., R. G. Packard Co., 130 Pearl St., New York City	Sept. 3, 1901
Palmer, William Pendleton. Pres., Am. Steel & Wire Co., Western Reserve Bldg., Cleveland, Ohio	Mar. 3, 1896
Parsons, George Wellman. Cons. Engr., Pennsylvania Steel Co., Steelton, Pa	Sept. 3, 1884
Patton, Alfred Gaunt. Engr. and Chf. of the Special Hazard Dept. of the New York Fire Insurance Exchange, The Oaks, Fisher's Lane, Germantown, Philadelphia, Pa	Dec. 6, 1905
Phelps, Earle Bernard. Cons. San. Engr., 30 Church St., New York City	Mar. 4, 1908
Philbrick, Burton Garfield. Bacteriologist of Eaton-Philbrick Laboratories, 444 Market St., San Francisco, Cal	Oct. 31, 1911
Phillips, Henry Ayling. Archt., 120 Tremont St., Boston, Mass	April 7, 1886
Pinchot, Gifford. 1615 Rhode Island Ave., N. W., Washington, D. C	Mar. 4, 1902
Polk, William Anderson. Chamber of Commerce Bldg., Baltimore, Md	May 4, 1897
Pomeroy, Lewis Roberts. 50 Church St., Room 1175, New York City	April 2, 1890
Poorman, Alfred Peter. Asst. Prof. of Mechanics, Purdue Univ., 127 Sylvia St., West Lafayette, Ind	Oct. 7, 1908
Price, Charles Pearl. Mgr., Am. Tar Co., 201 Devonshire St., Boston, Mass	May 2, 1911
Quincy, Charles Frederick. Pres., Q. & C. Co., 90 West St., New York City	Feb. 4, 1896
Ransome, Ernest Leslie. Cons. Concrete Engr., 910 Madison Ave., Plainfield, N. J	June 5, 1894
Ray, David Heydorn. Chf. Engr., Bureau of Bldgs., New York City, 220 Fourth Ave., New York City. (*Jun., Oct. 7, 1902*)	Mar. 1, 1910
Ross, Charles Wilson. Street Commr., City of Newton, City Hall, West Newton, Mass	Feb. 28, 1911
Rowntree, Bernard. Eastern Mgr., Burdett-Rowntree Mfg. Co., 50 Church St., New York City	April 5, 1910
Ryan, Laurence Patrick. Contr. (T. L. Ryan & Co.), 4047 Kenmore Ave., Chicago, Ill	Aug. 31, 1909
Saeger, Charles Marshall. Gen. Mgr., Coplay Cement Mfg. Co., 1320 Hamilton St., Allentown, Pa	May 2, 1893
Sass, Charles William. Asst. Engr., Board of Water Supply (Res., 465 East 140th St.), New York City	Nov. 4, 1908
Scherer, George Cheever. Chf. Clerk, U. S. Engr. Office, Box 763, Montgomery, Ala	Oct. 3, 1911
Scribner, Gilbert Hilton, Jr. 108 South La Salle St., Room 614, Chicago, Ill	April 5, 1905
Sell, William Drumm. Chf. Engr., West Virginia Coal Land Co.; Asst. Gen. Mgr., Ohio Timber Co., Room 400, National City Bank Bldg., Charleston, W. Va. (*Jun., Dec. 3, 1891*)	May 2, 1899
Smith, Albert. Prof. of Structural Eng., Purdue Univ., 1022 Seventh St., West Lafayette, Ind	April 3, 1907
Smith, Cameron C. Pres. and Gen. Mgr., Union Steel Casting Co., Pittsburgh, Pa	June 5, 1907
Smith, Francis Hopkinson. 16 Exchange Pl., New York City	April 5, 1892
Smith, Francis Vinton. Hotel Belnord, 86th St. and Broadway, New York City	Oct. 7, 1908
Smith, Herbert Stearns Squier. Prof. of Civ. Eng., Princeton Univ., 58 University Pl., Princeton, N. J	Sept. 10, 1891
Smith, Jonathan Rhodes. Engr., The Jobson Gifford Co., 25 East 26th St., New York City	Dec. 5, 1911
Smith, Walter Townsend. 1123 Broadway, Room 1206, New York City.	Oct. 7, 1908
Snare, Frederick. Pres., The Snare & Triest Co., Contr. Engrs., 143 Liberty St., New York City	Oct. 6, 1903
Sommer, Albert. Care, The Barber Asphalt Paving Co., Land Title Bldg., Philadelphia, Pa	Feb. 1, 1910

ASSOCIATES S-Y

	Date of Membership
Speed, James Breckinridge. 325 West Main St., Louisville, Ky.	May 2, 1888
Stilson, Minott Augur Osborn. 151 Plaza Ave., Waterbury, Conn.	Feb. 5, 1908
Stowe, Charles Brown. Pres., The Stowe Fuller Co., Cleveland, Ohio.	Oct. 4, 1898
Stroebe, George Gottlieb. Care, Bureau of Public Works, Manila, Philippine Islands	Nov. 4, 1908
Struckmann, Holger. Chf. Engr. and Gen. Mgr., Iola Portland Cement Co., Iola, Kans	Nov. 30, 1909
Talbot, Frank Mayhew. Pres. of F. M. Talbot Co., Contrs., 1 Madison Ave., New York City (Res., Glen Ridge, N. J.)	May 4, 1909
Tenney, George Oliver. Pres., Atlantic Bitulithic Co., Mutual Bldg., Richmond, Va. (*Jun., Sept. 7, 1887*)	Feb. 5, 1901
Thorn, Alfred William. Gen. Mgr., Thorn Cement Co., 445 Delaware Ave., Buffalo, N. Y.	Oct. 2, 1900
Toch, Maximilian. Chemist for Toch Bros., 320 Fifth Ave., Room 709, New York City	Sept. 1, 1903
Tomkins, Calvin. Commr. of Docks, Pier A, North River, New York City	Jan. 6, 1886
Townsend, Frederick Eugene. 311 West 95th St., New York City	April 6, 1909
Trautwine, John Cresson, Jr. 257 South 4th St., Philadelphia, Pa.	Dec. 5, 1888
Vanderkloot, William John. Secy. and Treas., South Halsted St. Iron Works, 2611 South Halsted St., Chicago, Ill.	May 2, 1911
Van Name, Joseph Mason. 788 Riverside Drive, New York City	April 3, 1907
von Schrenk, Hermann. Supervisor, Timber Preservation, Frisco-Rock Island System, Tower Grove and Flad Aves., St. Louis, Mo.	July 10, 1907
Walker, Charles Leopold. Asst. Prof., Applied Mechanics, Cornell Univ., 218 University Ave., Ithaca, N. Y. (*Jun., April 6, 1909*)	Feb. 28, 1911
Warder, John Haines. Secy., Western Society of Engrs., 1735 Monadnock Blk., Chicago, Ill.	Mar. 7, 1888
Watson, Merrill. Mgr., Watson Eng. Co., 40 West 32d St., New York City	Oct. 7, 1902
Watt, James Robert. Pres., United Constr. Co., 467 Broadway, Albany, N. Y.	June 3, 1908
Weber, George Adam. 71 Courtland Ave., Stamford, Conn.	Feb. 6, 1900
Wells, Joseph Agur. The Fairbanks Co., Broome and Elm Sts., New York City	Jan. 7, 1896
Willson, Frederick Newton. Prof. of Descriptive Geometry and Technical Drawing, Princeton Univ., Box 63, Princeton, N. J. (*Jun., Sept. 5, 1883*)	Oct. 4, 1892
Woodbury, John McGaw. Care, Gen. Elec. Co., 30 Church St., New York City	Feb. 7, 1906
Wrenn, James Francis. Gen. Contr., Box 601, Fayetteville, N. C.	Sept. 6, 1905
Young, Charles Griffith. Engr. and Contr., 60 Wall St., New York City	Mar. 6, 1894

Associates, 176.

JUNIORS

[Jun. Am. Soc. C. E.]

	Date of Membership
Abrams, Duff Andrew. Associate, Eng. Experiment Station, Univ. of Illinois, Urbana, Ill	Jan. 2, 1906
Abrons, Louis William. Asst. to Pres., Rutland Mfg. Co., Rutland, Vt	Aug. 31, 1909
Ackemann, Henry Conrad. Grants Pass, Ore	Feb. 1, 1910
Ackerman, Arthur Pope. Topographer and Draftsman, Dept. of Public Works, Santo Domingo, Santo Domingo	June 30, 1910
Affleck, Myron Hopkins Strong. Engr., Rumford Chemical Works, Rumford, R. I	Feb. 4, 1908
Alderman, Ernest Samuel. 2511 Dwight Way, Berkeley, Cal	Oct. 3, 1911
Allaire, Douglas Anthony. 2265 Eighty-fourth St., Brooklyn, N. Y	June 30, 1911
Alvarez, Arthur Carl. Instr. in Civ. Eng., Univ. of California, 1909 Dwight Way, Berkeley, Cal	Dec. 5, 1911
Amadon, Frederick Webber. Asst. Engr., Room 308, Office Bldg., N. Y., N. H. & H. R. R., New Haven, Conn	June 30, 1911
Anderson, Lowrey Wallace. Gen. Mgr. and Chf. Engr., The Pecos Val. Southern Ry., Pecos, Tex	April 6, 1909
Andrus, Leonard Alexander. 912 Lewis Bldg., Portland, Ore	Jan. 7, 1908
Anschuetz, Otto William Julius. Draftsman, Mo. Val. Bridge & Iron Co., Leavenworth, Kans	May 2, 1911
Appel, Harris Arkush. 1657 Gaylord St., Denver, Colo	Mar. 2, 1909
Armstrong, George Simpson, Jr. Care, Carpenter Steel Co., Reading, Pa	Jan. 5, 1909
Atwood, Chester Ely. Office Engr., Care, Ford, Bacon & Davis, Valier, Mont	Feb. 1, 1910
Atwood, William Bartlett. Vice-Pres. and Gen. Mgr., Geneva & Auburn Ry., Seneca Falls, N. Y	April 30, 1907
Auten, Claude Isaac. City Engr., Flint, Mich	Sept. 1, 1908
Ayres, Louis Evans. With Gardner S. Williams, Cons. Engr., 303½ South State St., Ann Arbor, Mich	Dec. 1, 1908
Backus, Murray James. Asst. Engr., Irrig. Service, Guayama, Porto Rico	Oct. 4, 1910
Bailey, Clifton George. Sub-Insp., U. S. Naval Station, Key West, Fla	Sept. 6, 1910
Bailey, Thomas Sherwood. Leveler, New York State Barge Canal, 530 Rugby Rd., Schenectady, N. Y	Feb. 28, 1911
Baines, William Henry. 569 Jersey Ave., Jersey City, N. J	Sept. 6, 1910
Baker, Ned Duncan. Asst. San. Engr., Haviland & Tibbetts, San Francisco, Cal	Dec. 6, 1910
Baldridge, James Ramsey. Superintending Engr., Hennebique Const. Co., Key West, Fla	Dec. 4, 1906
Banks, Charles Wilbur. Asst. Engr., Board of Water Supply, Box 456, Pleasantville Station, N. Y	Feb. 5, 1907
Banta, Russell Vincent. 11 Washington Pl., Ridgewood, N. J	May 31, 1910
Barker, James Madison. 20 Oxford St., Pittsfield, Mass	Oct. 1, 1907
Barlow, Alfred Eugene, Jr. 854 Lafayette Ave., Brooklyn, N. Y	April 2, 1907
Barnes, Harry Everett. Asst. Engr., Board of Water Supply, Box 69, Newburgh, N. Y	Mar. 2, 1909
Barney, William Joshua. Second Deputy Commr. of Docks, Pier A, North River, New York City	April 5, 1910
Barshell, Frederick Bayard. Asst. Civ. Engr., Public Service Comm., First Dist., State of New York, 154 Nassau St., New York City	May 1, 1906
Bartholomew, Tracy. Mgr., Western Cement Products Co., 1161 Humboldt St., Denver, Colo	Jan. 3, 1911
Bartlett, William Andrews. 2220 North Nevada Ave., Colorado Springs, Colo	Jan. 31, 1911
Bates, Lindon, Jr. 71 Broadway, New York City	Jan. 3, 1907
Battie, Herbert Scandlin. Erection Dept., Pennsylvania Steel Co., Steelton, Pa	Dec. 1, 1908
Beall, Pendleton. Instrumentman, N. Y. C. & H. R. R. R., 318 Mill St., Poughkeepsie, N. Y	June 6, 1911
Bean, Paul Jones. Civ. Engr., U. S. N., Navy Yard, Norfolk, Va	May 2, 1911
Beard, Vivian Dangerfield. Box 384, Ambridge, Pa	April 5, 1910
Becker, Rudolph Conrad. 339 East 68th St., New York City	April 30, 1907

JUNIORS B

	Date of Membership
Beebe, John Cleaveland. Junior Engr., U. S. Forest Service, Missoula, Mont	Nov. 1, 1910
Beebee, Ralph Agustus. 551 University Ave., Palo Alto, Cal	Sept. 1, 1908
Beggs, George Erle. 423 West 118th St., New York City	Oct. 3, 1911
Behrman, Isadore. 1121 East Baltimore St., Baltimore, Md	Oct. 4, 1910
Bell, Howard Fred. Engr. and Surv., Cody, Wyo	May 31, 1910
Bellows, Sidney Raymond. Barge Canal Terminal Office, 1219 Whitehall Bldg., New York City	Oct. 1, 1907
Benedict, Nathan. Asst. Engr., United Fruit Co., Limon, Costa Rica	Oct. 1, 1907
Bennet, Orville Green, Jr. Vice-Pres. and Mgr., Gen. Motors Export Co., 103 Park Ave., New York City	June 5, 1906
Bergman, Harry Montifiore. Supt. for Godwin Constr. Co., 30 Church St. (Res., 514 West 122d St.), New York City	May 4, 1909
Bernstein, Lester. Asst. Engr., Operating Dept., B. & O. R. R., B. & O. Bldg., Baltimore, Md	Feb. 28, 1905
Beswick, James Everett. Asst. Engr., Board of Water Supply, New York City (Res., 5 Wiener Pl., Tompkinsville, N. Y.)	July 1, 1909
Bhâgwat, Shanker Râmchandra. Lecturer in Eng., Coll. of Science, 192 Sadashiv Peth, Poona City, India	Oct. 4, 1910
Bigelow, William Walter. Care, J. R. Worcester & Co., Waltham, Mass	Feb. 1, 1910
Biggs, Carroll Addison. Designer for William G. Fargo, 219 West Franklin St., Jackson, Mich	Sept. 1, 1908
Billwiller, Ernest Oswald. 167 Washington Ave., San José, Cal	Nov. 8, 1909
Bilyeu, Charles Smith. 201 West 87th St., New York City	Dec. 1, 1908
Black, James Buckley. Structural Engr., Reinforced Concrete Co., 1609 Wright Bldg., St. Louis, Mo	June 6, 1911
Black, Roger Derby. First Lieut., Corps of Engrs., U. S. A., U. S. Engr. Office, Albany, N. Y	Jan. 3, 1905
Blackburn, Nathaniel Townsend. U. S. Junior Engr., U. S. Engr. Office, Galveston, Tex	Sept. 6, 1904
Blakeslee, Harold Law. Kitchawan, N. Y. (Res., 501 George St., New Haven, Conn.)	Dec. 5, 1911
Bleistein, Bernard Joseph. Asst. Engr., Dept. of Water Supply, Gas and Electricity; Res., 240 Jamaica Ave., Astoria, N. Y	April 4, 1911
Blight, Arthur Frederick. Care, Stone & Webster Constr. Corporation, Auberry, Cal	Feb. 28, 1911
Bloemker, Harold William. 1939 North 19th St., Philadelphia, Pa	Oct. 31, 1911
Bluhm, Herman William. Draftsman, Isthmian Canal Comm., Corozal, Canal Zone, Panama	Nov. 8, 1909
Bock, Carl August. Care, Caribbean Constr. Co., Port au Prince, Haiti	Aug. 31, 1909
Bogert, Clinton Lathrop. Asst. Engr., Headquarters Dept., Board of Water Supply, 299 Broadway, New York City	Sept. 1, 1908
Boig, Alexander Fletcher. Care, Am. Bridge Co., Ambridge, Pa	Nov. 1, 1910
Bolton, Frank Leonard. Mgr., New York Reclamation Co., 800 Cutler Bldg., Rochester, N. Y	June 30, 1910
Booth, Raymond. 30 Centre St., City Island, New York City	June 30, 1911
Borland, Bruce. 1508 Borland Blk., Chicago, Ill	Mar. 3, 1903
Bornefeld, Charles Fowler. Insp., Galveston Causeway, 2509 Broadway, Galveston, Tex	May 31, 1910
Bossert, Carl Donald. Asst. County Engr., Columbiana County, Washingtonville, Ohio	Oct. 31, 1911
Bowditch, Ernest W. Landscape Gardener and Civ. Engr., 68 Devonshire St., Boston, Mass	Feb. 3, 1875
Bowerman, Edwin Roy. Contract Engr., H. S. Kerbaugh, Inc., Fairport, N. Y	Jan. 3, 1911
Bowman, Ralph McLane. Solicitor of U. S. and Foreign Patents, 720 McGill Bldg., Washington, D. C	Feb. 28, 1911
Brainerd, Harold Affleck. 501 Westfield Ave., Westfield, N. J	Nov. 30, 1909
Brann, Emmett Raymond. State Highway Dept., Warren, Pa	Dec. 6, 1910
Breitzke, Charles Frederick. Asst. Engr., Johnson & Fuller, 150 Nassau St., New York City	Dec. 3, 1907
Brennan, Joseph Lawrence. Bureau of Lands, Manila, Philippine Islands	Jan. 5, 1909
Brewer, Willard Seymour. Asst. Engr. in Chg. of Sewers, City Engr.'s Office, Hartford, Conn	Sept. 3, 1907
Bringhurst, John Henry. Houston, Tex	Jan. 3, 1911
Brittain, Karl Walthall. Res. Engr., Intrenchment Creek Sewage Disposal Plant, Care, Chf. of Constr., Atlanta, Ga	Jan. 3, 1911
Broadhurst, William George. Contr. Engr., 245 Passaic St., Hackensack, N. J	Sept. 3, 1907
Bronson, Howard Franklin. Hydrographer, Box 15, Gatun, Canal Zone, Panama	Nov. 1, 1910
Brooks, John Nixon. 240 W. State St., Trenton, N. J	Nov. 8, 1909
Brooks, Josiah Richardson. Asst. Engr., Key West Extension, Florida East Coast Ry., Long Key, Fla	Feb. 2, 1909

	Date of Membership
BROOKS, RAYMOND WENTWORTH. Hartford, Iowa	Jan. 2, 1912
BROWN, ARTHUR ROBERT. Office of Asst. Chf. Engr., Culebra, Canal Zone, Panama	Jan. 2, 1906
BROWN, CLARENCE COWGILL. Care, Baxter L. Brown, 610 Merchants-Laclede Bldg., St. Louis, Mo	Feb. 28, 1911
BROWN, CLAUDE OSGOOD. Asst. Engr., Bureau of Public Works, Manila, Philippine Islands	Oct. 5, 1909
BROWN, DAVID HARELL. Engr., M. of W., Salt Lake & Ogden Ry., Box 240, Ogden, Utah	Feb. 4, 1908
BROWN, WILLIAM CLINTON. Care, Humphrey Gas Pump Co., S. A. & K. Bldg., Syracuse, N. Y	Sept. 1, 1886
BRUA, ELMER GEORGE. Mgr., R. of W. and Tax Dept., Associated Oil Co., Wells Fargo Bldg., San Francisco, Cal	Feb. 6, 1906
BRYAN, GEORGE, JR. Asst. to Contr. Agt., Am. Bridge Co. of N. Y., 3833 Alta Vista Terrace, Chicago, Ill	Jan. 3, 1911
BUCHANAN, NATHAN BOOKER. Huntsville, Ala	Mar. 1, 1910
BUCK, ROSS JUDSON. Chf., Survey Party No. 12, Bureau of Lands, Manila, Philippine Islands	June 30, 1911
BUDELL, ALFRED EDWARD. 95 Liberty St., New York City	Oct. 1, 1907
BUELL, WALTER AUGUSTUS. Care, The Union Sulphur Co., Sulphur, La	Oct. 4, 1910
BUETTNER, OTTO GEORGE HENRY. Asst. Engr., Interborough Rap. Trans. Co., 32 Park Pl., New York City	May 31, 1910
BURNHAM, GEORGE EARLE. Care, Manila Ry., Manila, Philippine Islands	Oct. 1, 1907
BURR, MYRON CARLOS. Civ., Hydr. and Min. Engr. (Burr & Ferguson), Loo Bldg., Vancouver, B. C., Canada	May 4, 1909
BURTON, WAYNE JOSEPH. Div. Engr., Mo. Pac. Ry., Pueblo, Colo	Sept. 4, 1906
BURTON, WILLIAM ARTHUR. Care, Paris & Mt. Pleasant R. R., Paris, Tex	June 6, 1911
BUSHELL, ARTHUR WILLIAM. Bureau of Lands, Manila, Philippine Islands.	Oct. 1, 1907
BUSHWAY, WALTER BENJAMIN. Asst. Engr., Boston Elev. Ry., 69 Bradford Ave., Roslindale, Mass	Nov. 8, 1909
CADWALLADER, WALLACE LAIRD. Asst. Engr., N. Y. C. & H. R. R. R., Room 5140, Grand Central Terminal, New York City	Sept. 6, 1910
CAHILL, JOHN RICHARD. 460 Montgomery St., San Francisco, Cal	April 30, 1907
CALDER, JOHN WEBSTER. Instr. in Math., Southern Manual High School, Philadelphia, Pa	Sept. 1, 1908
CALDWELL, JOHN WORDE. Care, City and County Engr., Honolulu, Hawaii.	Aug. 31, 1909
CALKINS, CHARLES DOW. Instr. in Math. and Surveying, Rensselaer Polytechnic Inst., 23 Thirteenth St., Troy, N. Y	April 5, 1910
CAMERON, KENNETH MACKENZIE. Dist. Engr., Public Works, Dept. of Canada, P. O. Box 29, Sherbrooke, Que., Canada	Oct. 6, 1903
CANTWELL, HERBERT HERLUIN. Asst. Supervisor of Track, N. Y. C. & H. R. R. R., Croton, N. Y	Dec. 3, 1907
CARLISLE, ORVILLE BERTON. Designer, Am. Bridge Co. (Res., 4318 Calumet Ave.), Chicago, Ill	Sept. 4, 1906
CARPENTER, J. C. Asst. Engr., Bureau of Public Works, Manila, Philippine Islands	Nov. 8, 1909
CARPENTER, JAMES WILHELM. Field Engr., The Cleveland Elec. Illuminating Co., 2074 E. 83d St., Cleveland, Ohio	Feb. 28, 1911
CARTER, LESTER LEVI. Room 817, Sheldon Bldg., San Francisco, Cal	Sept. 3, 1907
CARTWRIGHT, HENRY HART. With Lewisburg & North. R. R., 1508 Sigler St., Nashville, Tenn	Oct. 4, 1910
CARY, RICHARD LUCIUS. 23 Madison St., Princeton, N. J	June 30, 1910
CASPARI, FREDERICK WILLIAM. Asst. Engr., Baltimore Sewerage Comm., 902 American Bldg., Baltimore, Md	Nov. 1, 1910
CASTILLO Y GRAU, ANTONIO. P. O. Box 1669, Cienfuegos, Cuba	June 6, 1911
CATER, WALTER DAY. Civ. Engr. for the Am. Cement Eng. Co., Yorktown, Va	Nov. 30, 1909
CEFALU, FRANK DOMINIC. U. S. Junior Engr., Departmental Service, Burrwood, La	April 5, 1910
CHAFETZ, HERMAN. 80 Pratt St., Buffalo, N. Y	June 1, 1909
CHAMBERLAIN, JOSEPH JENKS, JR. 61 Oxford St., Cambridge, Mass	Oct. 3, 1911
CHANDLER, EMERSON LAWRENCE. Asst. Engr., New London Water and Sewer Dept. (Res., 16 Squire St.), New London, Conn	Nov. 8, 1909
CHANDLER, HORACE EDWARD. In Chg. of Dept. of Physics, Coll. of Arts and Sciences, Shantung Christian Univ., Weihsien, Shantung Province, China	Sept. 4, 1906
CHAPMAN, ARNOLD GOODWIN. Chf. Clerk, Dept. of State Engr. and Surv., State of New York, Albany, N. Y	July 1, 1909
CHESTER, CHARLES PORTER. With Stone & Webster Eng. Corporation, Fort Worth, Tex	Feb. 4, 1908
CHEVALIER, LOUIS. Prin. Asst. to J. E. Greiner, Cons. Engr., 1308 Fidelity Bldg., Baltimore, Md	May 1, 1906

	Date of Membership
Chevalier, Willard Townshend. Asst. Engr., Public Service Comm., 154 Nassau St., New York City	April 6, 1909
Church, Elihu Cunyngham. Lecturer in Civ. Eng., Columbia Univ.; Cons. Engr., 4 East 130th St., New York City	May 1, 1906
Clark, William George. Cons. Engr., 1050 Spitzer Bldg., Toledo, Ohio	April 4, 1888
Clausnitzer, John. 157 East 21st St., New York City	Mar. 3, 1903
Clayton, Henry Helm. Asst. Engr., M. of W. Dept., Mo. Pac. Ry., Kirkwood, Mo	Dec. 3, 1907
Cleveland, Lou Baker. Civ. Engr. and Contr., Cleveland Bldg., Watertown, N. Y	Sept. 1, 1908
Clifford, Walter Woodbridge. Hydr. Engr., U. S. Forest Service, Henry Bldg., Seattle, Wash	Nov. 8, 1909
Clift, William Brooks. 240 McCallie Ave., Chattanooga, Tenn	Oct. 31, 1911
Coburn, Horace Butterfield, Jr. 93 West Park St., Portland, Ore	Oct. 30, 1906
Cochran, Jerome. Designing Engr., Trussed Concrete Steel Co., Trussed Concrete Bldg., Detroit, Mich	Sept. 1, 1908
Coffin, Theodore DeLong. Katonah, N. Y	Nov. 1, 1904
Cohen, Jacob Xenab. Asst. Engr., Hering & Gregory, 170 Broadway, New York City	Oct. 3, 1911
Cole, Alden Brigham. Asst. Engr., N. Y., O. & W. Ry., Carbondale, Pa	Sept. 3, 1907
Cole, Ernest Delavan. Constr. Engr., Associated Oil Co., Oil Center, Cal	Oct. 31, 1911
Coleman, Lester Lyman. Maricopa, Kern Co., Cal	May 31, 1910
Colgan, Robert Joseph. 226 N. 2d St., Harrisburg, Pa	Sept. 1, 1908
Colman, James Blaine Thomas. Care, F. J. Colman, R. F. D. No. 36, Middleport, N. Y	Nov. 1, 1910
Coombs, Arthur Wellesley. Engr. and Contr., R. D. Coombs & Co., 1123 Broadway, New York City	Oct. 1, 1907
Corp, Henry William. Res. Engr., Manila R. R., Manila, Philippine Islands	Oct. 1, 1907
Cortright, Edwin Keen. Asst. Engr. with B. H. Davis, Cons. Engr., 215 West 23d St., New York City	Feb. 4, 1908
Crandall, Lynn. 615 Idaho Bldg., Boise, Idaho	Dec. 6, 1910
Crane, Will Edwin. 800 Walnut St., Edgewood Park, Swissvale P. O., Pittsburgh, Pa	May 1, 1889
Craven, Jay Allen. Care, Indiana State Board of Health, Indianapolis, Ind.	May 31, 1910
Croasdale, Laurence Brodhead. Delaware Water Gap, Pa	May 31, 1910
Crocker, Foster Baldwin. Care, Barge Canal Office, R. F. D. No. 5, Rome, N. Y	June 30, 1911
Crotty, John James. 420 Exchange Bldg., Memphis, Tenn	June 6, 1911
Crowell, Francis Stirling. Asst. Engr., Barge Canal Contract No. 69, Barge Canal Office, Mechanicsville, N. Y	Feb. 6, 1906
Culley, Massena Laron. 672 North St., Jackson, Miss	Dec. 5, 1911
Cunningham, John Wilbur. Draftsman, Bridge Dept., Oregon-Washington R. R. & Nav. Co., 920 Paulsen Bldg., Spokane, Wash	Aug. 31, 1909
Cunningham, Pinkney Edward. U. S. Junior Engr., P. O. Box 404, Vicksburg, Miss	July 1, 1909
Cunningham, William Augustine. 193^{a} Schaeffer St., Brooklyn, N. Y	June 30, 1911
Currey, John Waggoner. Deputy County Surv., Wagoner Co., Wagoner, Okla	Sept. 6, 1910
Cutler, Leon George. Care, Board of Water Supply, 165 Broadway, New York City	April 5, 1910
Cutler, Stanley Gardner. 2332 Monroe St., Chicago, Ill	May 4, 1909
Cykler, Emil Frank. Structural Engr. with H. J. Brunnier, 1739 Euclid Ave., Berkeley, Cal	Oct. 31, 1911
Davenport, Royal William. Junior Engr., U. S. Geological Survey, 207 Tilford Bldg., Portland, Ore	Oct. 4, 1910
Davila, Lorenzo Juan. Juana Diaz, Porto Rico	June 30, 1911
Davis, Daniel Elias. 932 Johnson St., Madison, Wis	Feb. 28, 1911
Davis, George Walker. Surv., Bureau of Lands, Manila, Philippine Islands	Feb. 4, 1908
Davis, Roland Parker. Associate Prof., Structural and Hydr. Eng., West Virginia Univ., Morgantown, W. Va	Mar. 1, 1910
Davison, Allen Stewart. Secy. and Treas., McGuire & Davison, 2512 Oliver Bldg., Pittsburgh, Pa	Mar. 1, 1910
Day, Warren Ellis. Care, Maj. R. U. Patterson, Fort Banks, Mass	Dec. 6, 1910
Decker, Arthur James. Instr. in Civ. Eng., Univ. of Michigan, 816 East Ann St., Ann Arbor, Mich	Sept. 5, 1905
de Forest, Nora Blatch. Asst. Engr. and Chf. Draftsman of the Radley Steel Constr. Co., 624 East 19th St., New York City	Mar. 6, 1906
de Mey, Edouard Jean Bernard. Levelman, Constr. Dept., B. &. O. S. W. R. R., 63 Carew Bldg., Cincinnati, Ohio	Jan. 2, 1912

	Date of Membership
Dennie, Frank Edward. Univ. of Missouri, School of Mines and Metallurgy, Rolla, Mo	Oct. 5, 1909
Densler, Frank Haskell. Asst. Engr., Board of Water Supply, New York City	July 1, 1909
Derleth, Walter Taubert. Engr. with D. J. Ryan, Contr., 723 Third Ave., Brooklyn, N. Y. (Res., 224 West 139th St., New York City)	Oct. 31, 1905
Deutschbein, Harry Johnson. Supt., Bureau of Water, 25 Quackenbush St., Albany, N. Y	Dec. 6, 1904
Dibert, Herbert McMillen. With W. & L. E. Gurley, 514 Fulton St. (Res., 139 North Maple Ave.), Troy, N. Y	April 6, 1909
Dimmler, Charles Louis. Care, Am. Bridge Co., Gary, Ind	Oct. 1, 1907
Dittoe, William Henry. Acting Chf. Engr., Ohio State Board of Health, 909 Harrison Bldg., Columbus, Ohio	May 3, 1910
Dodds, David Metheny. Draftsman, Am. Bridge Co., 6223 Greenwood Ave., Chicago, Ill	Nov. 1, 1910
Doering, Aloysius Henry. Engr. of Designs and Estimates, Riverside Bridge Co., Martins Ferry, Ohio	April 4, 1911
Donle, Earl Raymond. Hartley Hall, Columbia Univ., New York City	Oct. 31, 1911
Doolittle, Frederick William. Asst. Prof. of Mechanics, Univ. of Wisconsin, 204 North Brooks St., Madison, Wis	April 5, 1910
Dorrance, Frank Young. With Morris Knowles, Cons. Engr., Room 2548, Oliver Bldg., Pittsburgh, Pa	Feb. 5, 1907
Dougherty, Richard Erwin. Dist. Engr., N. Y. C. & H. R. R. R., Grand Central Palace, New York City	Jan. 6, 1903
Dow, Edwin Arthur. 320 East Davenport St., Iowa City, Iowa	Oct. 31, 1911
Drager, Walter Louis. City Engr.'s Office, Schenectady, N. Y	May 3, 1910
Drake, Ralph Edmund. Leveler, New York State Eng. Dept., Barge Canal, Seneca Falls, N. Y	Jan. 31, 1911
Driggs, Edwin Leroy. 720 Herran, Manila, Philippine Islands	Nov. 5, 1907
Dubois, Gustavo Adolfo. Jefatura del Alcantarillado, Havana, Cuba	Sept. 1, 1908
Duff, Carl Mathias. 1045 Regents St., Boulder, Colo	Sept. 5, 1911
Du Moulin, Walter Louis. Supt., The Morenci Water Co., Morenci, Ariz.	Feb. 1, 1910
Dunan, George Edmund. Chf. Engr., Apalachicola Northern R. R., Port St. Joe, Fla	Nov. 8, 1909
Dunlap, Walter Hanna. The Consolidation Coal Co., Jenkins, Ky	Oct. 31, 1911

Eames, Horace Lovell. 134 Washington Ave., Bridgeport, Conn	Jan. 7, 1908
Earl, Austin Willmott. 743 Twenty-first St., San Diego, Cal	Dec. 1, 1908
Earle, Frank Hasbrouck. 163 North 7th St., Newark, N. J	Dec. 4, 1906
Easton, Russell Burns. City Engr., Aberdeen and Redfield, S. Dak., 17 Second Ave., S. E., Aberdeen, S. Dak	Mar. 3, 1908
Eberly, Virgil Allen. Care, C. M. Saville, Culebra, Canal Zone, Panama.	June 6, 1911
Eberspacher, Fred. Box 159, Birmingham, Ala	Mar. 2, 1909
Eddy, Adolphus James. Instr. in Civ. Eng., Univ. of California, 2630 Fulton St., Berkeley, Cal	Dec. 6, 1910
Edgerton, Glen Edgar. First Lieut., Corps of Engrs., U. S. A., Alaska Road Comm., Valdez, Alaska	Nov. 8, 1909
Edmundson, Harold Bowen. Care, State Board of Public Roads, Providence, R. I	Nov. 30, 1909
Eide, Torris. Asst. Engr., Designing Div., Board of Water Supply, 165 Broadway, New York City	Sept. 6, 1910
Ellis, Herbert Cram. Insp., New York Board of Water Supply, White Plains Club, White Plains, N. Y	April 5, 1910
Eltinge, Orville Lamont. Draftsman, Sewer Div., City Engr.'s Office, Kansas City, Mo	Jan. 3, 1907
Emigh, William Chester. Purling, N. Y	May 31, 1910
Emory, Lloyd Tilghman. Cons. Engr. (Emory & Eisenberg), 1103 Harrison Bldg., Philadelphia, Pa	Oct. 5, 1909
Enger, Arthur Ludwig. Instr., Highway Eng., Polytechnic Inst., Brooklyn, N. Y	Jan. 2, 1912
Entenmann, Paul Max. Asst. Engr., Public Service Comm., First Dist., 317 Sixth Ave., Brooklyn, N. Y	Mar. 1, 1910
Estabrook, George Mitchell. Asst. Engr. with C. E. Marshall, Hempstead, N. Y	Feb. 4, 1908
Esten, Howard Foss. 128 Cedar St., Pawtucket, R. I	Jan. 2, 1906
Estes, Lewis Alden. Asst. to Mgr., Foreign Trade Dept., The Trussed Concrete Steel Co., Detroit, Mich	June 30, 1911

Faidley, Lloyd Harrison. 4812 Hammett Pl., St. Louis, Mo	Dec. 5, 1911
Farley, Marcus Martin. Atwood, Ulster Co., N. Y	Sept. 4, 1906
Farrington, Harold Phillips. Care, Vielé, Blackwell & Buck, 49 Wall St., New York City	April 5, 1910
Faucette, William Dollison. Chf. Clerk to the Pres., Seaboard A. L. Ry., 24 Broad St., New York City	Jan. 6, 1903

	Date of Membership
Feeley, William Patrick. 645 Prospect Ave., Buffalo, N. Y.	May 2, 1911
Feigel, John Henry. 262 Orange St., Buffalo, N. Y.	Oct. 6, 1908
Ferris, Raymond West. With Akron Water-Works Co., in Chg., Chemical Disinfection of Water Supply, 55 Rose Ave., Akron, Ohio	May 3, 1910
Feustel, Robert Maximilian. Asst. Engr., Wisconsin R. R. and Tax Comms., Madison, Wis.	May 4, 1909
Field, Clesson Herbert. Draftsman, Lackawanna Bridge Co., 193 Lockwood Ave., Buffalo, N. Y.	June 1, 1909
Finch, James Kip. Instr. in Civ. Eng., Columbia Univ., New York City	June 4, 1907
Finch, Stanley Phister. Instr. in Civ. Eng., Univ. of Texas, 2306 San Antonio St., Austin, Tex.	Oct. 30, 1906
Fitting, Harold Hansen. Care, Duryea, Haehl & Gilman, 1315 Humboldt Bank Bldg., San Francisco, Cal.	May 2, 1911
Flagg, Herbert Judson. 5015 Seventeenth Ave., N. E., Seattle, Wash.	Oct. 3, 1911
Fleeger, Burtner. With Pittsburgh Steel Foundry, Glassport, Pa., 428 Kelly Ave., Wilkinsburg, Pa.	Dec. 6, 1910
Flick, John Kramer. Engr. of Surveys, Baltimore City Water Dept., Loch Raven, Md.	Jan. 31, 1911
Flynn, George Augustus. 298 St. John Ave., Westerleigh, N. Y.	Jan. 31, 1911
Forbes, Francis Bonner. 8 West 56th St., New York City	May 3, 1910
Forsyth, Harold Frederick. Constr. Engr. for Chas. E. Moore & Co. of San Francisco, Hotel Van Decar, Vancouver, B. C., Canada	Mar. 2, 1909
Foss, James Calvin, Jr. Chf. Engr., Kahului R. R., Kahului, Maui, Hawaii	April 6, 1909
Foster, Herbert Bismarck. San Engr. for Univ. of California, Berkeley, Cal.	Sept. 3, 1907
Foulds, Roberts Shepherd. Asst. Engr., Phœnix Bridge Co., 216 Morgan St., Phœnixville, Pa.	Feb. 5, 1907
Foulkrod, Frederick Shelton. Asst. Engr. in Designing and Estimating Office, McClintic-Marshall Constr. Co., Pittsburgh, Pa.	Oct. 31, 1911
Fox, William Frederick. Asst. to Rd. Engr., Interborough Rapid Transit Co., M. of W. Dept., 108 East 22d St., New York City	April 5, 1910
Frazer, James Stanley. 184 Warburton Ave., Yonkers, N. Y.	Jan. 2, 1906
French, Roger DeLand. Lecturer, Municipal Eng., McGill Univ.; Prin. Asst. Engr., R. S. Lea, 405 Dorchester St., West, Montreal, Que., Canada	Mar. 6, 1906
Frisbie, Henry Charles. Care, W. G. McConnel, Rio Janeiro Tramway, Light & Power Co., Caixa 571, Rio de Janeiro, Brazil	Oct. 4, 1910
Frost, Willis George. Highway Engr., San Mateo County, Redwood City, Cal.	Dec. 5, 1911

Gaiger, Frank Millard. 66 Brookside Ave., Mt. Vernon, N. Y.	Jan. 7, 1908
Galvin, James Augustine. Archt. and Constr. Engr., Remsen and Ontario Sts., Cohoes, N. Y.	Sept. 3, 1907
Gard, Hermon Yancy. Care, Troy Wagon Works, Troy, Ohio	Jan. 4, 1910
Gardner, Harry Carter. Instr., Civ. Eng., Univ. of Pennsylvania, 3718 Walnut St., Philadelphia, Pa.	July 1, 1909
Gardner, Henry James, Jr. Prin. Asst. Engr., Ricker & Minniss, 702 Ellicott Sq., Buffalo, N. Y.	Oct. 31, 1911
Garnett, Benjamin Jay. Draftsman, City Engr.'s Office, E. 1918 Mission Ave., Spokane, Wash.	Nov. 1, 1910
Garvey, Victor Hugo. 7633 Bagley Ave., Seattle, Wash.	Nov. 1, 1910
Garvin, Edgerton Chester. Junior Engr., U. S. Engr. Dept., Augusta, Ga.	Dec. 3, 1907
Gates, Marshall DeMotte. Asst. Engr., M. of W., C. G. W. R. R., Des Moines, Iowa	Mar. 31, 1908
Gates, Warren Austin. Architectural Engr., Layton & Smith, 701 Majestic Bldg., Oklahoma, Okla.	June 30, 1911
Gay, Robert Walter. Prof. of Civ. Eng., Mississippi Agri. and Mech. Coll., Agricultural College, Miss.	Oct. 6, 1903
Gaylord, Clifford Willard. Mgr., Constr. Dept., Keystone Fireproofing Co., 1123 Broadway, New York City	Oct. 4, 1910
Gaynor, Keyes Christopher. City Engr., Sioux City, Iowa	June 30, 1910
Germer, Wilhelm Eduard. Care, Mr. Jouett, N. Y. C. & H. R. R. R., 335 Madison Ave., Room 1222½ (Res., 1424 Crotona Park, East, Bronx), New York City	Aug. 31, 1909
Gibble, Isaac Oberholzer. Asst. Engr., The United Fruit Co., Bocas del Toro, Panama	Nov. 8, 1909
Gilkison, Gordon Mercer. Care, The Telluride Power Co., Provo, Utah	Nov. 1, 1910
Gill, Harold Earle. 822 President St., Brooklyn, N. Y.	Nov. 1, 1910
Gilland, Thomas Omar. Berwind Fuel Co., Superior, Wis.	Sept. 4, 1906
Gillelen, Frank. 604 Wright and Callender Bldg., Los Angeles, Cal.	May 1, 1906
Gillespie, Chester Gordon. San. Engr., Hollister, Cal.	Sept. 6, 1910
Giquel, Rafael Sanchez. Engr. in Chg., Central Highway, Havana Province, Calle 6, No. 18, Vedado, Havana, Cuba	Feb. 4, 1908

	Date of Membership
Glander, John Henry, Jr. Asst. Engr. with Charles W. Leavitt, Jr., 220 Broadway, New York City	May 3, 1910
Godfrey, Stuart Chapin. Lieut., Corps of Engrs., U. S. A., Schofield Hall, Fort Leavenworth, Kans	Sept. 5, 1911
Goodrich, Thomas MacLenathen. 1009 Yeon Bldg., Portland, Ore	Sept. 3, 1907
Gordon, Samuel. Asst. Civ. Engr., U. S. N., Navy Yard, Mare Island, Cal.	Oct. 4, 1910
Gotwals, John Carl. Asst. Engr., Board of Water Supply, New York City, Yorktown Heights, N. Y	May 5, 1908
Gould, Chester Mason. Asst. Engr., Board of Water Supply, New York City, Cold Spring, N. Y	April 6, 1909
Gould, John Warren Du Bois. 30 Church St., New York City	Oct. 7, 1902
Graham, Germain Paul. Asst. Engr. in Chg., River Front Impvts., 400 Morris St., Albany, N. Y	Nov. 8, 1909
Graham, Guy Alexander. Engr. with Snare & Triest Co., Contract 62, New York City Board of Water Supply, Box 243, Peekskill, N. Y.	Sept. 6, 1910
Graham, John William. Acting Dist. Engr., Province of Misamis, Cagayan, Misamis, Philippine Islands	Oct. 4, 1910
Graham, Leo Daniel. Care, U. S. Reclamation Service, Ronan, Mont	June 1, 1909
Gram, Ralph Samuel. 218 La Salle St., Room 922, Chicago, Ill	Mar. 3, 1908
Grannis, James Kidwell. Engr., H. L. Stevens & Co., Fort Worth, Tex.	Sept. 6, 1910
Gray, Harold Farnsworth. San. Engr., 2540 Benvenue Ave., Berkeley, Cal	Jan. 4, 1910
Gray, Roy Cecil. Highway Engr., Chariton County, Keytesville, Mo	Oct. 3, 1911
Greathead, John Francis. Junior Engr., Public Service Comm., First Dist., 170 West 97th St., New York City	Mar. 3, 1908
Greeley, Samuel Arnold. Winnetka, Ill	Feb. 5, 1907
Green, Arthur Brooks. 19 Orkney St., Woodfords, Me	Jan. 31, 1911
Green, Clarence Jasper. 714 Lewis Bldg., Portland, Ore	Sept. 1, 1908
Green, Nathaniel Warren. City Engr., Helena, Ark	Dec. 5, 1911
Gregson, Alvero Charles. 43 Hillside Ave., Flushing, N. Y	May 4, 1909
Griffin, Augustus. Engr. and Supt., Modesto Irrig. Dist., Modesto, Cal.	Oct. 30, 1906
Grindrod, Irvin Sutton. 33d and Clearfield Sts., Philadelphia, Pa	Feb. 2, 1909
Griswold, Horace Seth. C. E. Bldg., Univ. of California, Berkeley, Cal.	Jan. 31, 1911
Gross, Charles Aaron. Structural Steel Salesman, Bethlehem Steel Co., 109 West 4th St., South Bethlehem, Pa	Sept. 1, 1908
Gross, Joseph Watson. With Reynolds & Whitman, Cons. Engrs., 530 Forum Bldg., Sacramento, Cal	Sept. 1, 1908
Gurney, Lester. Chf. of Party, Western Div., Cape Cod Constr. Co., Buzzards Bay, Mass	Dec. 5, 1911
Hadley, Homer More. Asst. Engr., E. & N. Ry., Duncans, Vancouver Isl., B. C., Canada	April 5, 1910
Hale, Herbert Miller. Holbrook, Cabot & Rollins Corporation, 331 Madison Ave., New York City	Nov. 1, 1904
Hall, Charles Lacey. Second Lieut., Corps of Engrs., U. S. A., Manila, Philippine Islands	June 30, 1910
Hall, Joseph Emmett. Pres., J. E. Hall Co., 427 Board of Trade Bldg., Indianapolis, Ind	June 30, 1910
Hall, Julius Reed. Chf. Draftsman, Strauss Bascule Bridge Co., 902 Fort Dearborn Bldg., Chicago, Ill	June 6, 1905
Halsey, Milo Clinton. Box 587, Monrovia, Cal	June 30, 1910
Halsey, Wallace Haynes. Bridge Hampton, N. Y	Jan. 7, 1908
Halstead, George Elias. Montmorenci, Ind	June 30, 1911
Hamilton, Edward Parmelee. With Power Constr. Co., Shelburne Falls, Mass	April 6, 1909
Hamilton, William Edward. U. S. Insp., Pennington, Ala	Jan. 3, 1911
Hamlin, Horace Parlin. Designing Engr., Raymond Concrete Pile Co., 140 Cedar St., Room 1309, New York City	June 6, 1905
Hammel, Edward Frederic. Asst. Engr., Bureau of Bldgs. of Manhattan, 2686 Briggs Ave., New York City	Feb. 1, 1910
Hand, Richardson. 84 South St., Wilkes-Barre, Pa	Jan. 3, 1907
Hannah, Manton. Engr. of Highways, Paris, Tex	Nov. 1, 1910
Hardesty, Shortridge. Draftsman with Waddell & Harrington, 1012 Baltimore Ave., Kansas City, Mo	Sept. 1, 1908
Harding, Harry Spear. Asst. Engr., Board of Water Supply, City of New York, 165 Broadway, New York City	May 31, 1910
Harding, Sidney Twichell. Care, U. S. Irrig. Investigations, Berkeley, Cal	Sept. 5, 1905
Harrington, Arthur William. Asst. Engr., L. B. Cleveland, 403 Stone St., Watertown, N. Y	Dec. 6, 1910
Harrod, Tom Hind Hudson. Box 576, Augusta, Ga	Feb. 1, 1910
Hart, Laurance Hastings. Estimator on Valuation, L. V. R. R., Care, Div. Engr., Buffalo, N. Y	Oct. 3, 1911
Harvey, Michael Smith. Chf. Engr., Birmingham & N. W. Ry., Jackson, Tenn	April 30, 1907

	Date of Membership
Harwi, Solomon Jacob. City Engr., Bayonne, N. J.	Dec. 4, 1889
Haselton, Gage. Asst. Engr., S. P. Co., 247 Stout St., Portland, Ore.	May 3, 1904
Hastings, Hudson Bridge. Reed Coll., Portland, Ore.	Oct. 5, 1909
Hatch, Everett Hamilton. 142 Hugo St., San Francisco, Cal.	Nov. 5, 1907
Hatch, Frederick Nathaniel. Asst. Engr., Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City	June 4, 1907
Hathaway, Clifford Murray. Asst. Engr. with Arthur H. Blanchard, Cons. Highway Engr., Columbia Univ., New York City	Sept. 1, 1908
Havens, William Westerfield. 469 East 134th St., New York City	Dec. 6, 1910
Hawley, Charles Burridge. Ishpeming, Mich.	May 4, 1909
Hayes, Ferdinand Eugene, Jr. With F. E. Hayes, Jr. & Co. 900 Lincoln Bldg., Louisville, Ky.	Feb. 4, 1908
Hayes, Harry Riddel. Secy. and Treas., George Merritt Ward, Inc., 158 West 58th St., New York City	Feb. 28, 1911
Hayman, Edgar Thomas. Road Engr. of Anne Arundel County, Box 235, Annapolis, Md.	Aug. 31, 1909
Hazen, Ralph William. Care, U. S. Reclamation Service, Powell, Wyo.	Nov. 30, 1909
Heilbronner, Leon Cohen. 238 Union St., Schenectady, N. Y.	Mar. 2, 1909
Heiser, Alfred Brackenridge. Draftsman, Turner Constr. Co., 11 Broadway, New York City (Res., 159 Twenty-third St., Brooklyn, N. Y.)	Nov. 1, 1910
Heiser, William Joseph. Structural Draftsman with Engr. of Structures, Exterior Zone, N. Y. C. & H. R. R. R., Grand Central Terminal, New York City (Res., 159 Twenty-third St., Brooklyn, N. Y.)	Nov. 1, 1910
Helling, Harry Albertus. Y. M. C. A. Bldg., Poughkeepsie, N. Y.	Jan. 3, 1911
Hemphill, William Lind. Surv., Bureau of Lands, Manila, Philippine Islands	Oct. 1, 1907
Henderson, John Taylor. Operating Engr., Big Lost River Irrig. Co., Arco, Idaho	Nov. 1, 1910
Hendrie, John Gibson. Asst. Engr., The Barber Asphalt Paving Co., 215 High St., Perth Amboy, N. J.	Sept. 5, 1911
Henes, Harry William. Mech. Engr. with A. Bolter's Sons, 118 North La Salle St. (Res., 2573 North Clark St.), Chicago, Ill.	May 31, 1910
Henry, Smith Tompkins. Dist. Representative, *Engineering Record,* 1021 Schofield Bldg., Cleveland, Ohio	Sept. 5, 1905
Herchkovitz, George Edward. Civ. Engr., State Board of Assessors, State House, Trenton, N. J.	June 30, 1911
Hess, John Strider. Care, Standard Oil Co., 461 Market St., San Francisco, Cal.	Oct. 5, 1909
Heyman, William. 325 Montgomery St., Jersey City, N. J.	June 30, 1911
Hickok, Clifton Ewing. Asst. Engr., Mt. Hood Ry. & Power Co., Bull Run, Ore.	Dec. 6, 1910
Hilder, Frazer Croswell. Eng. and Architectural Draftsman, Office of Indian Affairs, Washington, D. C.	Sept. 6, 1904
Hines, Homer Estle. Engr., M. of W., The Virginian Ry., Princeton, Mercer Co., W. Va.	May 5, 1908
Hinman, Leroy Race. 714 Ideal Bldg., Denver, Colo.	Feb. 5, 1907
Hirsch, John George. With Daniel W. Mead, Cons. Engr., Madison, Wis.	June 30, 1910
Hjorth, Lauritz Rasmus. Draftsman, Cleveland & Cameron, 506 Winch Bldg., Vancouver, B. C., Canada	June 30, 1911
Hogan, John Philip. Div. Engr., Esopus Div., Board of Water Supply, City of New York, High Falls, N. Y.	Dec. 6, 1904
Hohl, Leonard Louis. 612 Marvin Bldg., San Francisco, Cal.	Sept. 4, 1906
Holbrook, Arthur Raymond. Asst. Engr., Dept. of Water Supply, Gas and Electricity, Filtration Div., 13 Park Row, New York City	April 2, 1907
Holland, Howard Kingsbury. Asst. Engr. with Gardner S. Williams, 303½ South State St., Ann Arbor, Mich.	June 1, 1909
Holloway, Arthur Power. La Belle Iron Works, Steubenville, Ohio	Oct. 5, 1909
Holloway, Roger Tifft. 1170 Broadway, New York City	May 31, 1910
Holmes, Robert Leslie. Div. Engr., Tex. & Pac. Ry., Marshall, Tex.	Oct. 1, 1907
Holmes, Thomas Hughes. Broadway and Crosby Sts., Portland, Ore.	Jan. 4, 1910
Hopper, John Jacob. Civ. Engr. and Contr., 215 West 125th St. New York City	May 5, 1886
Horrigan, William James. Civ. Engr. and Pres., Horrigan Contr. Co., 507 Ford Bldg., Wilmington, Del.	June 1, 1909
Horton, John William. 2614 California Ave., Sacramento, Cal.	Sept. 1, 1908
Howard, Clement John. Eng. Dept., The Texas Co., Houston, Tex.	Sept. 6, 1904
Howe, Clarence Decatur. Dalhousie Univ., Halifax, Nova Scotia	Oct. 5, 1909
Howe, Frank Ray. Engr. and Supt., Queensboro Corporation, 66 Jamaica Ave., Flushing, N. Y.	June 1, 1909
Howes, Cyrus Pierce. Asst. Engr., Mo. Pac. Ry., Title Guarantee Bldg., St. Louis, Mo.	May 4, 1909
Howes, Donald Winthrop. Asst. Engr., Board of Water Supply, New Paltz, N. Y.	April 4, 1905
Howson, George William, Jr. Civ. and Hydr. Engr. with Ford, Bacon & Davis, 115 Broadway, New York City	Oct. 5, 1909
Hubbard, Daniel. Asst. Div. Engr., Bolivia Ry., Oruro, Bolivia	Dec. 6, 1910

	Date of Membership
HUFF, WALTER WILLIAM. Box 74, Sullivan, Ill	Nov. 30, 1909
HUGHES, NORMAN. Draftsman with Richmond Cedar Works (Res., 253 Freemason St.), Norfolk, Va	Dec. 6, 1910
HUGHES, WILLIAM RICHARD, JR. Care, C. M. Neeld Constr. Co., 1418 Oliver Bldg., Pittsburgh, Pa	June 1, 1909
HULL, GORDON BURNETT GIFFORD. Rangeworthy, Northfield, Birmingham, England	July 1, 1909
HUMPHREY, FREDERIC LEAROYD. 27 East Monroe St., Phœnix, Ariz	June 4, 1907
HUNTSMAN, FRANK C. Div. Engr., C., B. & Q. R. R., Alliance, Nebr	Sept. 5, 1905
HURDLE, REGINALD TRUMAN. Civ. Engr. and Surv. for Dawson County, Glendive, Mont	Oct. 1, 1907
HUTCHINS, EVERETT NELSON. Insp., Board of Water Supply, New York City, High Falls, N. Y	Jan. 31, 1911
HUTCHINS, ROLAND ELLIS. Instr., Civ. Eng., Brown Univ., Providence, R. I	Nov. 1, 1910
HUTH, CHRISTIAN. 1106 The Rookery, Chicago Ill	Jan. 3, 1911
HYDE, EDWARD WYLLYS, JR. Room 404, McKinnon Bldg., Toronto, Ont., Canada	Sept. 4, 1906
IRVIN, CHARLES RICHARD. (Irvin & Witherow), Keystone Bldg., Pittsburgh, Pa	Sept. 6, 1910
JERRARD, LEIGH PATTERSON. Engr.'s Office, Wisconsin R. R. Comm., Madison, Wis	Oct. 5, 1909
JOHNSON, DAVID CLAYTON. Asst. Engr., H. de B. Parsons, 22 William St., New York City (Res., 245 Hewes St., Brooklyn, N. Y.)	Sept. 1, 1908
JOHNSON, FRANK MELVIN. 1303 East Marion St., Seattle, Wash	Jan. 31, 1911
JOHNSON, GRANVILLE. 489 Walnut Ave., Jamaica Plain, Mass	Mar. 5, 1907
JOHNSTON, ANDREW CRAWFORD. Care, Pittsburgh Meter Co., East Pittsburgh, Pa	Sept. 1, 1908
JONES, BENJAMIN EARL. Junior Highway Engr., U. S. Office of Public Roads, Helena, Mont	April 6, 1909
JONES, PUSEY. Asst. Engr., Structural Dept., N. Y., Westchester & Boston Ry., Grand Central Terminal, New York City	Mar. 6, 1906
JONES, WILLIAM HENRY. 2186 Seventh Ave., West, Vancouver, B. C., Canada	Oct. 31, 1911
JORDAN, MYRON KENDALL. With H. S. Crocker, Cons. Engr., 308 Tramway Bldg., Denver, Colo	Mar. 1, 1910
JOSLIN, HAROLD VINCENT. Engr., Yadkin River Power Co., Contrs., Pee Dee, N. C	April 6, 1909
JOUINE, GEORGES PIERRE FERDINAND. U. S. Junior Engr., Box 404, Vicksburg, Miss	Oct. 6, 1908
KAESTNER, ALBERT CARL. 2216 Starling Ave., New York City	Jan. 2, 1912
KAHN, GUSTAVE EDMUND. Chf. Engr., Sterling Eng. & Constr. Co. and National Eng. & Constr. Co., Caswell Blk., Milwaukee, Wis	Sept. 6, 1904
KELLERSBERGER, ARNOLD CHARLES. Care, Crescent Pump Works, Fort Worth, Tex	Oct. 6, 1908
KELLOGG, RAYMOND CLINTON. Asst. to Supt., Street Main Dept., Dist. No. 2, The Brooklyn Union Gas Co., 5 Skillman St., Brooklyn, N. Y	April 4, 1911
KENNEDY, THOMAS PATRICK BERCHMANS. Pres. and Treas., Kennedy Constr. Co., 534 Broadway (Res., 138 Washington Ave.), Albany, N. Y	May 5, 1908
KESNER, HENRY JAMES. Asst. Prof. of Civ. Eng., Univ. of California, Berkeley, Cal	Dec. 6, 1910
KIENLE, JOHN ASPIN. Chf. Engr., Water Dept., Wilmington, Del	April 3, 1906
KILKENNY, TOBIAS DILLON. With Haviland & Tibbetts, 2360 Van Ness Ave., San Francisco, Cal	Oct. 6, 1908
KING, ARTHUR CASWELL. Asst. Engr., Water Dept. (Res., 43 Jefferson Ave.), Springfield, Mass	Sept. 4, 1906
KING, EDMUND GEDDES. With Charles F. King & Co., Contrs., 411 Land Title Bldg., Philadelphia (Res., 914 Mahantongo St., Pottsville), Pa.	Nov. 8, 1909
KING, ERIC TURE. Asst. Engr., Board of Water Supply of New York City, Cornwall-on-Hudson, N. Y	Feb. 5, 1907
KINGSLEY, GEORGE. Asst. Engr. with William J. Wilgus; Res., 960 Fox St., New York City	June 2, 1908
KINNEY, WILLIAM MORTON. Asst. Inspecting Engr., Universal Portland Cement Co., 522 Frick Bldg., Pittsburgh, Pa	Sept. 6, 1910
KIRKWOOD, HOWARD CAMBERNE. Engr., N. Y. Terminal Div., P. R. R., Pennsylvania Station, New York City (Res., 212 Barclay St., Flushing, N. Y.)	Feb. 4, 1908
KITTREDGE, FRANK ALVAH. Engr., State Road, 4130 Eleventh Ave., N. E., Seattle, Wash	Mar. 1, 1910

	Date of Membership
Klingner, Louis William. Res. Engr., Constr. Dept., C. P. Ry., Box 892, Smith's Falls, Ont., Canada	Oct. 31, 1911
Knight, Walter Joseph. Chf. Engr., Gilsonite Constr. Co., 720 Wainwright Bldg., St. Louis, Mo	May 5, 1908
Knutson, George Henry. Engr. with Wm. G. Fargo, Jackson, Mich	Aug. 31, 1909
Kohn, Arthur Hirsh. 21 North Lime St., Lancaster, Pa	Oct. 2, 1906
Krieger, Albert August. 1141 Cherokee Rd., Louisville, Ky	June 1, 1909
Kriegsman, Eugen Frederick. Asst. Engr., Office of City Engr., San Francisco, Cal	May 5, 1908
Kuchar, Frank Miles. 341 East 73d St., New York City	Oct. 3, 1911

Lapham, John Raymond. 112 West Beaver Ave., State College, Pa	Nov. 8, 1909
Larimer, Robert Sherman. Wendell, Idaho	June 1, 1909
Latimer, Claude Alfred. 566 West 162d St., New York City	Oct. 31, 1911
Leach, Thomas. 341 Selby St., Westmount, Que., Canada	June 30, 1910
Learned, Albert Preisach. With Worley & Black, Cons. Engrs., Reliance Bldg., Kansas City, Mo	Dec. 6, 1910
Leete, Robert Burt. Draftsman, Canadian Bridge Co., Walkersville, Ont., Canada (Res., 641 Cass Ave., Detroit, Mich.)	Jan. 3, 1911
Lemcke, Karl Wolfgang. Care, Erection Dept., The Pennsylvania Steel Co., Steelton (Res., 129 North 4th St., Harrisburg), Pa	June 1, 1909
Leonard, Edward Philip. Care, The Elec. Bond & Share Co., 71 Broadway, New York City	May 3, 1910
Leonard, Oliver Yeaton. Box 314. San Juan, Porto Rico	Nov. 8, 1909
Letton, Harry Pike. Field Asst., Div. of Sewerage and Water Supplies, State Board of Health, Trenton, N. J	Feb. 1, 1910
Lewis, Chester Brooks. Supt. of Constr., Holabird & Roche, 1618 Monadnock Bldg., Chicago, Ill	Nov. 5, 1907
Lightner, George W Cass. Engr., Bridges and Bldgs., G. T. Ry., Toronto, Ont., Canada	Feb. 28, 1911
Lillich, Joseph Thomas. Div. Commercial Engr., New York Telephone Co., 14 West Seneca St., Buffalo, N. Y	Nov. 3, 1903
Lilly, Ridgely Casey. U. S. Junior Engr., Third Dist., Mississippi River Comm., Box 404, Vicksburg, Miss	Oct. 5, 1909
Lincoln, Edward Lewis. Asst. Engr., Board of Water Supply of New York City, 75 Fisher Ave., White Plains, N. Y	May 3, 1910
Lindsay, Richard Lee. Care, Guantanamo Sugar Co., Guantanamo, Cuba.	Sept 4, 1906
Lindsley, Thayer. Telluride, Colo	Jan. 3, 1905
Lisman, Oliver Cromwell. Care, Constr. Dept., Ala., Tenn. & North. R. R., York, Ala	Jan. 7, 1908
Long, Clarence Edward. Draftsman, Carnegie Steel Co.; Instr. in Math., Carnegie Technical Schools (Res., 341 Atwood St.), Pittsburgh, Pa	Sept 5, 1911
Longwell, John Stalker. Junior Engr., U. S. Reclamation Service, Boise, Idaho	Oct. 3, 1911
Lowry, John, Jr. Contr. and Builder, 160 Fifth Ave., New York City	Feb. 4, 1908
Lubarsky, Louis Henry. 60 Beaver St., New York City	Feb. 5, 1907
Lucchetti-Otero, Antonio Sebastian. Asst. Engr., P. R. I. S., Guayabal, Juana Diaz, Porto Rico	Jan. 3, 1911
Lundgren, Emil Leonard. Project Engr., Bureau of Public Works, Manila, Philippine Islands	Feb. 4, 1908
Lyerly, Charles Abner, Jr. 501 Oak St., Chattanooga, Tenn	Feb. 1, 1910
Lynch, Alexander Sydney. Engr., Southfield Point Co., Stamford, Conn.	Dec. 6, 1910
Lynde, Clifford. Asst. Engr., Board of Water Supply, City of New York, Walden, N. Y	Dec. 1, 1908
Lynde, Harry Milton. Walden, N. Y	April 4, 1911
Lynn, Henry Hudson Edwin. Asst. to Herbert C. Keith, Cons. Engr., 116 Nassau St., Room 901, New York City	May 5, 1908

MacIlvaine, Francis Shippen. 154 West State St., Trenton, N. J	Mar. 3, 1908
Mack, George Horace. Field Draftsman, Davenport-Muscatine Ry., Care, K. C. Weedin, Davenport, Iowa	Sept 6, 1910
Macklem, Norris Raymond. Manila, Philippine Islands	April 2, 1907
Macy, Frank Henry. Care, State Water Supply Comm., Albany, N. Y	Jan. 3, 1911
McCaffrey, John William. 43 Spring St., Woonsocket, R. I	Jan. 31, 1911
McCandliss, Wallace Highland. Care, Spanish American Iron Co., Felton, Oriente, Cuba	Jan. 7, 1908
McClave, Stephen Wood, Jr. With McClave & McClave, Borough Hall, Cliffside Park, N. J	Jan. 3, 1907
McClure, Harry Clifford. Asst. Engr., Dept. of Architecture, Board of Education, Y. M. C. A., Toledo, Ohio	Mar. 1, 1910
McClure, Hunter. Draftsman, Am. Bridge Co., 132 Sumac St., Wissahickon, Philadelphia, Pa	Jan. 4, 1910

	Date of Membership
McCrory, Sol. 518 Sixth St., Charleston, Ill	Oct. 6, 1903
McCrory, Thomas George. Asst. Chf. Engr., International Contract Co., 501 Central Bldg., Seattle, Wash	Dec. 1, 1908
McDaniel, George Glenn. U. S. Engr. Office, Room 665, Monadnock Bldg., San Francisco, Cal	Mar. 5, 1907
McDowell, William Hunter. Asst. Superv., P. & R. Ry., Spring Garden Station, Philadelphia (Res., Narberth), Pa	Dec. 5, 1911
McKean, Harry Parker. Valparaiso, Ind	June 6, 1911
McKinney, Francis William. Asst. Engr., Baltimore Sewerage Comm., American Bldg., Baltimore, Md	Mar. 31, 1908
McMullen, Ray Webb. 149 Broadway, New York City	June 30, 1910
McWethy, LeRoy. 909 Phelan Bldg., San Francisco, Cal	Jan. 4, 1910
McWilliams, Samuel Alexander. Morrowville, Kans	Oct. 3, 1911
Maglott, George Frederick. 39th St. Pumping Station, 39th St. and Lake Michigan, Chicago, Ill	Oct. 4, 1910
Mahone, William, Jr. 130 Freemason St., Norfolk, Va	April 5, 1910
Malcomson, Alfred Sidney. Municipal and Civ. Engr. (Smith & Malcomson), 37 Railroad Ave., Freeport, N. Y	Mar. 3, 1908
Malmros, Nils Lorentz Alfred. 111 First St., Yonkers, N. Y	Jan. 31, 1911
Malony, Walden Le Roy. Asst. to City Engr., Bridge Dept., P. O. Box 1078, Spokane, Wash	Aug. 31, 1909
Malsbury, Omer Evert. Junior Engr., I. C. C., Culebra, Canal Zone, Panama	Feb. 5, 1907
Manzanilla y Carbonell, José Justo. Asst. Engr., Huston Contr. Co., Isabela de Sagua, Santa Clara, Cuba	June 30, 1910
Marsh, Charles Reed. Supt. of Constr., U. S. Public Bldgs., Treasury Dept., U. S. P. O., Ionia, Mich	June 30, 1910
Marsh, Emmett Lincoln. Asst. Engr., S. P. R. R., East Auburn, Cal	Mar. 5, 1907
Marston, Frank Alwyn. Asst. Engr. with Metcalf & Eddy, 14 Beacon St., Boston, Mass	Mar. 1, 1910
Martinez, Rolando Arnoldo. Div. Engr. in Chg. of Paving, Havana Sewer and Paving Contr., Malecon 31, Bajos, Havana, Cuba	Dec. 1, 1908
Massei, Caesar. Structural Draftsman, Virginia Bridge & Iron Works, 501 Eleventh Ave., S. W., Roanoke, Va	Jan. 2, 1912
Maxwell, Donald Hebard. Asst. Engr., Alvord & Burdick, 1417 Hartford Bldg., Chicago, Ill	April 5, 1910
Maynard, Henry Warner. Brown Hoisting Machinery Co., Cleveland, Ohio	Dec. 3, 1907
Mehren, Edward John. Secy. and Mgr., The Emerson Co., 30 Church St., New York City	Oct. 30, 1906
Mendenhall, Herbert Drummond. Lakeland, Fla	Sept. 4, 1906
Menefee, Ferdinand Northrop. 1009 Packard St., Ann Arbor, Mich	June 30, 1911
Menke, William. Asst. Engr., New York Board of Water Supply, 3 West 63d St., New York City	Dec. 6, 1910
Merrill, Robert Hall. Asst. Engr., Barge Canal Office, Medina, N. Y	May 3, 1904
Merriman, Richard Mansfield. San. Engr., Dept. of the Interior, Govt. of Porto Rico, San Juan, Porto Rico	Jan. 3, 1907
Merritt, Charles Edward. 351 Genesee St., Utica, N. Y	Jan. 4, 1910
Messer, Hope Richard. State San. Eng., Dept. of Health, 1110 Capitol St., Richmond, Va	Oct. 4, 1910
Mieth, Richard Elam. Mgr., Portland Bridge & Iron Co., Portland, Ore.	May 1, 1906
Millard, Curtiss. Engr., M. of W., C. G. W. R. R., Des Moines, Iowa	April 3, 1889
Miller, Garner Wakefield. Instrumentman and Office Engr. with W. E. Ayres, 616 Randolph Bldg., Memphis, Tenn	Jan. 2, 1912
Miller, Harold Edmund. Asst. Engr., Rhode Island State Board of Public Roads, 73 Glenham St., Providence, R. I	Oct. 1, 1907
Miller, Hugh. Prof. of Civ. Eng., Clarkson School of Technology, 1 Chestnut St., Potsdam, N. Y	Nov. 30, 1909
Mills, Adelbert Philo. Asst. Prof. of Civ. Eng., Coll. of Civ. Eng., Cornell Univ., Ithaca, N. Y	Sept. 3, 1907
Mischke, Alexander. Engr. of Ways of Communication; Prin. Asst., Chf. Engr., Warsaw Govt. Terminal Ry. Constr., 16 Jouravlinaya, Warsaw, Russia	Oct. 5, 1909
Mitchell, William Washington. Res. Engr., Big Blackfoot Ry., Bonner, Mont	April 2, 1907
Monett, Harry. 2401 Durant Ave., Berkeley, Cal	Oct. 3, 1911
Monk, Percy Shelley. Junior Engr., U. S. Geological Survey, Federal Bldg., Newport, Ky	June 30, 1911
Moore, James Gates. Res. Engr., Florida Coast Line Canal & Trans. Co., Fort Pierce, Fla	Aug. 31, 1909
Moore, Stanley Wallace. Estimator, Sage Foundation Homes Co., 36 Bay 5th St., East Elmhurst, N. Y	July 1, 1909
Moore, Walter Smyth. Asst. Engr., L. & N. R. R., Pensacola, Fla	Dec. 6, 1910
Morgan, William Richard. Supt., R. B. Smith, Inc., 17 Madison Ave., New York City	Jan. 31, 1911
Morrison, Christopher George. Asst. Engr., Dist. No. 8, Bureau of Public Works, Philippine Islands, Albay, Albay, Philippine Islands	Oct. 5, 1909

	Date of Membership
Morrison, Roger Leroy. Instr. in Civ. Eng., Univ. of Tennessee, 505 West Main Ave., Knoxville, Tenn.	April 4, 1911
Moser, Albert Leo Brecht. Care, E. A. Moser, Cripple Creek, Colo.	Jan. 3, 1907
Mott, Thomas Clayton. Eng. Insp., Board of Water Supply, 826 Diamond Ave., Woodhaven, N. Y.	May 3, 1910
Moulton, Oren McKenney. Altmar, N. Y.	April 2, 1907
Muchemore, Harrie Langdon. Expert Aid, Public Works Dept., Puget Sound Navy Yard, 820 Seventh St., Bremerton, Wash.	Mar. 1, 1910
Mudd, John Posey. Engr., Midvale Steel Co., Philadelphia, Pa.	Jan. 2, 1912
Muir, Alexander Wicliffe. 156 Main St., Newton, N. J.	Jan. 3, 1911
Munkelt, Frederick Hermann. 668 East 13th St., Brooklyn, N. Y.	April 5, 1910
Murphy, Alvin Rush. Asst. Engr., The Pitometer Co., 220 Broadway, New York City.	June 6, 1911
Murphy, James Francis. Asst. Engr., Board of Water Supply, 503 West 124th St., New York City.	May 31, 1910
Murphy, Leo Francis. Sales Engr., The Central Heating Co., Detroit, Mich.	Sept. 5, 1911

Nagel, Theodore. (Nagel & Petersen), 514 Equity Bldg., Muskogee, Okla.	Dec. 6, 1910
Nawn, Hugh. 188 Seaver St., Roxbury, Mass.	Jan. 31, 1911
Neal, Clarence Adkins. Secy., Union Bridge & Constr. Co., 903 Sharp Bldg., Kansas City, Mo.	Dec. 6, 1904
Nelson, Ernest Benjamin. Draftsman, Isthmian Canal Comm., Box 443, Cristobal, Canal Zone, Panama.	Oct. 31, 1911
Nelson, Jabez Curry. Engr. with Ford, Bacon & Davis, 115 Broadway, New York City.	Oct. 1, 1907
Neuhardt, Edwin. With The Pearson Eng. Corporation, Ltd., 25 Broad St. (Res., 502 West 136th St.), New York City.	Nov. 8, 1909
Newton, George Cheney. Engr., Newton Eng. Co., 434 Jackson St., Milwaukee, Wis.	Feb. 4, 1908
Nichols, John Robert. Instr. in Civ. Eng., Harvard Univ., 82 Avon Hill St., Cambridge, Mass.	June 1, 1909
Nikirk, Frank Austin. 394 North 5th St., San José, Cal.	April 2, 1907
Nitchie, Francis Raymond. Bureau of Standards, Washington, D. C.	Jan. 3, 1911
Nordwell, Alfred Worcester. 18 Lake Ave., Oakland, Cal.	June 1, 1909
Norwood, Edgar Alva. 19 Mason St., Medford Hillside, Mass.	Nov. 30, 1909

O'Donnell, Charles Jerome. Asst. Engr., Board of Water Supply of New York City, R. F. D. No. 4, Newburgh, N. Y.	April 5, 1910
Ogier, George Rufus. 1121 First National Bank Bldg., Denver, Colo.	Jan. 4, 1910
Okes, Day Ira. Chf. Engr., The Kettle River Co., 302 Hennepin Court, Minneapolis, Minn.	Mar. 1, 1910
O'Neil, Harry Bernard. 234 Williams St., Providence, R. I.	Nov. 1, 1910
O'Reilly, Francis Sheridan. 110 Flower City Park, Rochester, N. Y.	Jan. 4, 1910
Osborn, Kenneth Howard. Insp. of Reinforced Concrete, Dept. of Bldgs. (Res., 1724 East 79th St.), Cleveland, Ohio.	Oct. 5, 1900
Ottosen, Peter Hill. Lieut., Coast Artillery Corps, U. S. A., Fort Ward, Wash.	Oct. 6, 1908
Overocker, Daniel Willets. Asst. Engr., Barge Canal Office, Canajoharie, N. Y.	Oct. 4, 1910
Owen, Kenneth Dunham. Montclair, N. J.	Feb. 6, 1906

Page, Stephen Eugene. Box 21, Perth Amboy, N. J.	June 30, 1911
Pagon, William Watters. With J. E. Greiner, Cons. Engr., Fidelity Bldg. (Res., 1301 St. Paul St.), Baltimore, Md.	Sept. 3, 1907
Paine, George Hebard. 6932 Lakewood Ave., Chicago, Ill.	Nov. 5, 1890
Paret, John Waldo. Care, Wichita Falls & Northwestern Ry., Trail, Okla.	Feb. 1, 1910
Parker, Kingsbury Eastman. 645 Monadnock Bldg., San Francisco, Cal.	May 5, 1908
Parlin, Raymond Washington. Res. Engr., Washington County Water Co., 116 West Washington St., Hagerstown, Md.	June 30, 1910
Parrigin, Frank Snow. Asst. Engr., Fla. East Coast Ry., P. O. Box 196, St. Augustine, Fla.	May 3, 1910
Parsons, Maurice Giesy. Stanford University, Cal.	Oct. 3, 1911
Patterson, Earl. U. S. Reclamation Service, Selden, Dona Ana Co., N. Mex.	April 30, 1907
Patterson, Irving Wooster. Highway Constr. Engr., The Texas Co., 8 Patterson Court, Waterville, Conn.	Jan. 4, 1910
Paul, Theodore Lochart. Rodman, N. Y., N. H. & H. R. R., Union Station, Worcester, Mass.	Feb. 1, 1910
Payne, George Amos. Engr. and Supt. of Constr., 92 Leroy St., Binghamton, N. Y.	Sept. 5, 1911

	Date of Membership
Payne, James Elwood. Designing Engr., Reinforced Concrete, 761 South 20th St., Newark, N. J.	June 6, 1911
Payrow, Harry Gordon. Instr. of Civ. Eng., Tufts Coll., Tufts College, Mass.	Feb. 4, 1908
Peck, Charles Franklin. Structural Engr., 1115 Oak St., Kalamazoo, Mich.	April 2, 1907
Peck, John Calvin. Office of the Div. Commercial Engr., New York Telephone Co. (Res., 273 Hamilton St.), Albany, N. Y.	Sept. 1, 1908
Pemberton, James Rex. Gauger and Pumper, Union Oil Co., Balboa, Canal Zone, Panama	May 2, 1911
Perrine, Harold. Asst. Dept. of Civ. Eng., Columbia Univ., New York City	Sept. 5, 1911
Perry, John Prince Hazen. Mgr., Contr. Dept., Turner Constr. Co., 11 Broadway, New York City	Nov. 1, 1904
Perry, Lynn Elwood. Secy. and Engr., Perry-Bradley Lumber Co., Salisbury, Md.	Sept. 1, 1908
Peterson, Garfield Christian. Gen. Mgr., Guantanamo & Western R. R., Guantanamo, Cuba	Oct. 2, 1906
Phillips, Clifford French. Associated with Hiram Phillips, Cons. Engr., 1000 Third National Bank Bldg., St. Louis, Mo.	Nov. 30, 1909
Pill, Leon Morley. 1217 Tenth Ave., South, Birmingham, Ala.	Aug. 31, 1909
Pillet, Frederick Fischer. City Engr., Wilmington, N. C.	June 2, 1903
Poole, Ruble Isaac. Instr., Dept. of Civ. Eng., The North Carolina Coll. of Agri. and Mechanic Arts, Lock Box 128, West Raleigh, N. C.	Dec. 6, 1910
Poore, Herbert Carleton. Road Engr., Barrett Mfg. Co. of Boston, 94 Liberty St., East Braintree, Mass.	Jan. 31, 1911
Porter, Harry Franklin. Sheboygan, Wis.	Nov. 5, 1907
Potter, Edwin James. Y. M. C. A. Bldg., New Bedford, Mass.	Oct. 1, 1907
Powell, William Jenner. Asst. Engr., City Engr.'s Office, Dallas, Tex.	Jan. 2, 1906
Powers, Louis. 901 Madison Ave., Elizabeth, N. J.	Sept. 5, 1911
Price, Donald Douglas. State Engr., Lincoln, Nebr.	Sept. 6, 1910
Price, Joseph. 153 West Clifford St., Providence, R. I.	April 4, 1911
Price, Thomas Ernest. Care, Div. Engr., C. P. Ry., Vancouver, B. C., Canada	Jan. 31, 1911
Price, William Edmund. Engr., Layton & Smith, 701 Majestic Bldg., Oklahoma, Okla.	April 5, 1910
Proctor, Asa Glisson. City Engr., Woodland, Yolo Co., Cal.	Oct. 4, 1910
Pruett, Grover Cleveland. City Engr. and Supt., Water Plant, Miles City, Mont.	Mar. 2, 1909
Querbach, Earl. Draftsman, Am. Bridge Co., Ambridge (Res., 201 California Ave., Avalon), Pa.	Dec. 4, 1906
Rackle, Oscar William. 94 Angell St., East Side Station, Providence, R. I.	Sept. 4, 1906
Ramsdell, Robert Leroy. Address unknown	Oct. 6, 1908
Ramser, Charles Ernest. Care, Knoxville Power Co., Chilhowee, Tenn.	Mar. 1, 1910
Raschbacher, Harry George. Cons. Engr., 1213 Merchants Loan and Trust Bldg., Chicago (Res., 826 Madison St., Evanston), Ill.	May 2, 1905
Rathbun, John Charles. 4034 Fourteenth Ave., N. E., Seattle, Wash.	Oct. 6, 1908
Read, Bill. 167 Washington Ave., San José, Cal.	Nov. 8, 1909
Reed, Carl Sweetland. Eastern Sales Mgr., Bucyrus, Co., 50 Church St., New York City	Mar. 31, 1908
Reed, Frank Edward. With State Dept. of Highways, 63 Canvass St., Cohoes, N. Y.	April 6, 1909
Reed, Ralph John. With Union Oil Co. of California, Union Oil Bldg., Los Angeles, Cal.	Sept. 1, 1908
Reese, George Washington. Box 66, Y. M. C. A. Bldg., Denver, Colo.	May 31, 1910
Regester, Henry Slicer, Jr. Asst. Engr., Sewerage Comm., 908 American Bldg., Baltimore, Md.	Jan. 7, 1908
Reimann-Hansen, Robert Louis. Head Draftsman, B. & O. R. R., 3637 Park Heights Ave., Baltimore, Md.	Oct. 3, 1905
Rennell, Henry Hurd. Asst. Engr., United Rys. of Havana, Egido 2, Havana, Cuba	Mar. 3, 1908
Reynolds, Leon Benedict. 519 East State St., Ithaca, N. Y.	Oct. 4, 1910
Reynolds, Robert Albert. 134 Collingwood Ave., Detroit, Mich.	May 5, 1908
Rheinstein, Alfred. 344 West 89th St., New York City	Jan. 2, 1912
Rhodes, Glenn Vernon. Junior Asst. Engr., Board of Public Works, 152 Twelfth Ave., San Francisco, Cal.	May 3, 1910
Riblet, Harry Gaillard. With Caldwell & Drake, Bldrs., Columbus, Ind.; Res., The Chesterfield, Louisville, Ky.	Jan. 31, 1911
Rice, Rowland Grenville. 192 Summer St., Stamford, Conn.	Mar. 5, 1907
Rich, Wilder Meloy. U. S. Engr. Office, Sault Ste. Marie, Mich.	Sept. 3, 1907
Richards, Arthur. 407 Franklin Ave., Wilkinsburg, Pittsburgh, Pa.	Jan. 4, 1910

	Date of Membership
RINDSFOOS, CHARLES SIESEL. With The Foundation Co., 115 Broadway, New York City	April 2, 1907
ROBERG, RALPH MASON. Supt. of Constr., H. L. Stevens & Co., 1109 Korpen Bldg., Chicago, Ill	Sept. 6, 1910
ROBERTS, HAROLD WHITNEY. With Rapid Transit Subway Constr. Co., 165 Broadway (Res., 619 West 136th St.), New York City	Oct. 5, 1909
ROBERTS, RICHARD FRANCIS. Bridge Engr.'s Office, N. Y., N. H. & H. R. R., Room 314, Railroad Bldg. (Res., 9 Audubon St.), New Haven, Conn	May 31, 1910
ROBERTS, VINCENT. 1123 Broadway, New York City	Mar. 6, 1906
ROBINSON, WARD REID. Secy. and Chf. Examiner, Illinois Civil Service Comm., 1401 Williams Boulevard, Springfield, Ill	April 2, 1907
ROGERS, THOMAS FARWELL. 23 Willow St., San José, Cal	Mar. 5, 1907
ROLFE, ROBERT LAWRENCE. P. O. Box 1027, Memphis, Tenn	Sept. 5, 1911
ROLLINS, ANDREW PEACH. Swearingin McGraw Bldg., San Antonio, Tex.	May 4, 1909
ROMMEL, WILLIAM GUSTAVE. Asst. Engr. with T. C. Hatton, 233 Broome St., Wilmington, Del	Oct. 2, 1906
ROSSELL, PAUL FRANCIS. 1201 Clayton St., Wilmington, Del	Mar. 2, 1909
ROSSI, IRVING. Structural Draftsman, Milliken Bros., Inc., 138 Carteret Ave., Jersey City, N. J	Jan. 2, 1912
ROWE, WILFRED LINCOLN. Sunnyside, Wash	Mar. 31, 1908
RUSSELL, ALEXANDER ALLEN MACVICAR. 349 Frederick St., San Francisco, Cal	May 5, 1908
RUSSELL, ALEXANDER STUART. Engr. on Constr., El Segundo Refinery, S. O. Co., Box 175, Los Angeles, Cal	Oct. 6, 1908
RUTH, EDGAR KINGSBURY. Asst. Engr., Kaps-Brehm Co., 3022 Gilbert Ave., Cincinnati, Ohio	May 2, 1911
RYAN, RICHARD R. 926 Brown St., Sault Ste. Marie, Mich	Dec. 3, 1907
SACKETT, ARTHUR JOHNSON. Asst. Engr., Mason & Hanger Co., Cornwall-on-Hudson, N. Y	Mar. 1, 1904
ST. JOHN, WALTER SHERMAN. 341 Edgecombe Ave., New York City	Sept. 6, 1910
SANGER, WALTER MAX. State Dept. of Eng., Maxton, Ariz	May 5, 1908
SAXE, VAN RENSSELAER POWELL. Vice-Pres., Standard Concrete Steel Co., 218 East Lexington St., Baltimore, Md	Feb. 4, 1908
SCHEDLER, CARL WILLIAM, JR. Sheperdstown, W. Va	May 2, 1911
SCHMID, FRANCIS RAUCH. Bridge Designer, N. Y. C. & H. R. R. R., 7th Floor, Old Grand Central Palace, New York City	Oct. 6, 1903
SCHMID, ROBERT JOHN. Saskatoon, Sask., Canada	Feb. 2, 1909
SCHMIDT, THEODORE JOHN. Lumber Clerk, Standard Bridge Co., 1302 City National Bank Bldg., Omaha, Nebr	April 4, 1911
SCHMITT, JACOB. Asst. Engr., Bureau of Highways, Room 17, Municipal Bldg., Brooklyn, N. Y	June 2, 1903
SCHOBINGER, GEORGE. Asst. Engr., U. S. Reclamation Service, Yuma, Ariz.	Oct. 5, 1909
SCHOLTZ, HERMAN FRED. Asst. Engr., Erickson Const. Co., Dry Dock No. 2, Puget Sound Navy Yard, Bremerton, Wash	Oct. 30, 1906
SCHUYLER, MONTGOMERY. 6115 Berlin St., St. Louis, Mo	Sept. 1, 1908
SCOTT, JAMES ROBINSON, JR. Masonry Insp., Ill. Cent. R. R., Bridge and Bldg. Dept., 507 South State St., Champaign, Ill	Mar. 1, 1910
SCOTT, WALTER VANDERBELT. With McClintic-Marshall Const. Co., Pittsburgh (Res., 405 West St., Wilkinsburg), Pa	Nov. 8, 1909
SEARIGHT, GEORGE PETER. Insp., Board of Water Supply, Valhalla, N. Y.	Nov. 1, 1910
SEE, GEORGE CORLISS. Asst. Engr., Dept., State Engr. and Surv., Troy, N. Y	Sept 3, 1907
SEE, RUSSELL ALVA. Care, Kansas City Terminal Ry., 23d and Grand Ave., Kansas City, Mo	Oct. 4, 1910
SEELEY, HENRY ARTHUR. 1437 Park Ave., Bridgeport, Conn	Jan. 4, 1910
SEGUR, ASA BERTRAND. Chf. of Party, Morgan Eng. Co., Memphis, Tenn.	Jan. 3, 1911
SELBY, OSCAR ELLSWORTH. Engr. of Bridges and Structures, C., C., C. & St. L. Ry., Cincinnati, Ohio	Mar. 4, 1891
SELMER, WILLIAM LEE. Asst. Engr., Public Service Comm. of New York City, Hamilton Park, New Brighton, N. Y	Mar. 31, 1908
SELTZER, HYMEN AARON. Eng. Dept., Stupp Bros. Bridge & Iron Co., 5133 Fairmount Ave., St. Louis, Mo	May 2, 1911
SERRA, JULIUS HERSCHEL. 19 Halsey St., Brooklyn, N. Y	Jan. 3, 1911
SHANKLAND, RALPH GRAHAM. Supt. of Concrete Constr. for E. C. & R. M. Shankland, 1106 The Rookery Bldg., Chicago, Ill	Nov. 8, 1909
SHAPLEIGH, CHARLES HENRY. Chf. Engr., River, Rail & Harbor Constr. Co., 739 North State St., Jackson, Miss	June 30, 1910
SHARP, HOMER J. 1012 Security Bldg., Los Angeles (Res., 438 Pacific Ave., Long Beach), Cal	April 4, 1911
SHAW, WALTER FARNSBY. Care, Barge Canal Office, R. F. D. No. 5, Rome, N. Y	Jan. 4, 1910
SHELLEY, OSWALD PROCTER. Rialto Bldg., San Francisco, Cal	April 5, 1904
SHERMAN, ARTHUR LOUIS. Asst. Engr., Board of Water Supply of New York City, White Plains Club, White Plains, N. Y	Jan. 4, 1910

	Date of Membership
Sieling, Louis John. 539 Linwood St., Brooklyn, N. Y.	Feb. 1, 1910
Silsbee, James Alfred. Instrumentman, Power Constr. Co., Shelburne Falls, Mass.	April 4, 1911
Simpson, Charles Randolph. 201 Second St., Huntingdon, Pa.	Feb. 2, 1909
Sims, Harvey Hillyer. Care, Edible Products Co., 160 East 22d St., Bayonne, N. J.	May 4, 1909
Small, Gilbert. 428 Lexington St., Waltham, Mass.	June 1, 1909
Small, James Hampden, Jr. Engr., Ryan-Parker Constr. Co., 165 Broadway, New York City	Mar. 31, 1903
Smallman, Ralph Alcorn. Care, Fred A. Jones Bldg. Co., 1009 Empire Bldg., Birmingham, Ala.	Jan. 31, 1911
Smith, Charles Horton. County Engr., 16 East Main St., Middletown, N. Y.	June 4, 1890
Smith, Claire Howland Wallace. Blanca, Colo.	Dec. 5, 1911
Smith, Clarence Urling. 117 West 16th Ave., Spokane, Wash.	Sept. 5, 1911
Smith, Elroy George. P. O. Box 576, Augusta, Ga.	Sept. 1, 1908
Smith, Ford Cushing. Care, Rev. G. H. Smith, Rhinebeck, N. Y.	April 3, 1906
Smith, Francis Marshall. Roadmaster, N. P. Ry., Room 27, Second and King Sts., Seattle, Wash.	Jan. 3, 1907
Smith, George Washington. Chf. Engr., The Mark Process Co., Fisher Bldg., Chicago, Ill.	Jan. 31, 1911
Smith, Henry Boutwell. Engineering Hall, State Univ. of Iowa, Iowa City, Iowa	June 6, 1911
Smith, Joseph. Asst. Engr., Public Service Comm., 23 Flatbush Ave., Brooklyn, N. Y.	Feb. 2, 1909
Smith, Lewis Ruffner, Jr. 1115 Cedar Ave., Long Beach, Cal.	Dec. 6, 1910
Smith, Robert Hall, Jr. Masonry Insp., N. & W. Ry., Bandy, Va.	Dec. 5, 1911
Smith, Robert Mackinlay. 3 Westbourne Terrace, Kelvinside, Glasgow, Scotland	June 6, 1905
Smith, Roy Elmer. 2345 Minor Ave., North, Seattle, Wash.	June 30, 1911
Smith, Shaler Gordon. Care, Am. Gas Co., 222 South 3d St., Philadelphia, Pa.	July 1, 1909
Smith, William Durkee. 7357 Fourteenth Ave., N. W., Seattle, Wash.	Oct. 4, 1910
Smoyer, Lloyd Isadore. With Post & McCord, 44 East 23d St., New York City	Oct. 4, 1910
Smyth, Arthur Porter. Junior Engr., U. S. Reclamation Service, Powell, Wyo.	Jan. 3, 1911
Snook, Curtis Pendleton. 132 Bellevue Ave., Upper Montclair, N. J.	May 2, 1911
Snook, Thomas Edward, Jr. Engr. for John B. Snook's Sons, 73 Nassau St., New York City	Feb. 28, 1911
Snyder, Hubert Earl. Concrete Foreman, Isthmian Canal Comm., Gatun, Canal Zone, Panama	May 2, 1911
Snyder, Hunter Imboden. 14 Baldwin Bldg., Jacksonville, Fla.	Nov. 30, 1909
Soest, Hugo Conrad. Asst. Engr., Interborough Rapid Transit Co., 32 Park Pl., New York City	May 31, 1910
Soo-Hoo, Peter. Canton, China	Jan. 31, 1911
Spalding, Walter James. Asst. Engr., I. C. C., Balboa, Canal Zone, Panama	Nov. 1, 1904
Spaulding, Ralph Edgar. Eng. Contr. (E. N. & R. E. Spaulding), Suffield, Conn.	May 31, 1910
Speidel, Hugo S. Pres., The David Henry Bldg. Co., Cor., Main and Smith Sts., Paterson, N. J.	Feb. 5, 1890
Spencer, Charles Burr. Asst. Engr., R. F. Almirall, 1124 Pinton Ave., New York City	Oct. 3, 1911
Spengler, John Henry. 2347 Fifteenth St., Troy, N. Y.	June 6, 1911
Sperry, Austin Russell Willard. Chf. Engr., Crocker-Huffman Land & Water Co., Merced, Cal.	Dec. 6, 1910
Spooner, Charles Willett. Asst. Engr., Henry E. Riggs, Room 221, New Engineering Bldg., Ann Arbor, Mich.	Mar. 2, 1909
Sprague, Edwin Loring, Jr. Asst. Engr., Board of Water Supply, Valhalla, N. Y.	May 31, 1904
Stadel, George Henry. Civ. and Landscape Engr., Sound View Ave., Stamford, Conn.	Sept. 6, 1910
Stanton, Harry Seel. Junior Engr., U. S. Reclamation Service, Elephant Butte, N. Mex.	Oct. 4, 1910
Stanton, Robert Brewster, Jr. 315 Pearl St., Hartford, Conn.	Mar. 1, 1910
Starr, William H. 3 West 8th St., New York City	April 2, 1884
Steese, James Gordon. First Lieut., Corps of Engrs., U. S. A.; Asst. Engr., Chf. Engr.'s Office, Culebra, Canal Zone, Panama	Aug. 31, 1909
Steinman, David Bernard. Asst. Prof., Civ. Eng., Univ. of Idaho, Moscow, Idaho	Mar. 1, 1910
Stephenson, Grant Thomas. Gen. Supt., Mashek Chemical & Iron Co., Wells, Delta Co., Mich.	May 5, 1908
Stevenson, Ervin Beecher. 21 Clinton Ave., Albany, N. Y.	Jan. 31, 1911
Stewart, Charles Sumner. Draftsman, H. B. Sackett Screen & Chute Co. (Res., 2209 Monroe St.), Chicago, Ill.	Nov. 30, 1909
Stewart, Walter Phelps. U. S. Engr. Office, Louisville, Ky.	Nov. 8, 1909

	Date of Membership
Stewart, William James. First Asst. City Engr., Rochester, N. Y.	May 7, 1890
Stieve, William Matthew. Insp., Board of Water Supply, New York City, Cornwall-on-Hudson, N. Y.	June 30, 1911
Stiles, Albert Irvine. Constr. Dept., United Fruit Co., Barrios, Guatemala	Feb. 6, 1906
Stilson, Charles Edward. Care, Knoxville Power Co., Chilhowee, Tenn.	Mar. 1, 1910
Stirling, Vincent Reynolds. Asst. Engr., Moro Province, Zamboanga, Philippine Islands	Oct. 2, 1906
Stocker, Edward Charles. Instr. in Civ. Eng., Univ of Colorado, 302 West Wilson, Madison, Wis.	April 4, 1911
Stone, George Carter. Reinforced Concrete Draftsman, Lockwood, Greene & Co., 138 Lauriat Ave., Dorchester, Mass.	Jan. 2, 1912
Stone, James Hammond. Engr. in Chg. of Constr., Carretera del Oeste, Care, H. F. D. Burke, Director Gen., Santo Domingo, Santo Domingo	Mar. 31, 1908
Stow, Mulford. Insp., New York Board of Water Supply, Box 44, Wallkill, N. Y.	Sept. 3, 1907
Strain, Benjamin. Asst. Engr., Cent. N. E. Ry., Maybrook, N. Y.	April 5, 1910
Strandberg, George Robert. Instr. in Civ. Eng., Univ. of Washington, Univ. Station, Seattle, Wash.	Dec. 5, 1911
Strehan, George Ernest. Asst. Engr., Bureau of Bldgs., Borough of Manhattan, 220 Fourth Ave. (Res., 677 East 238th St.), New York City	Oct. 3, 1911
Strohl, Richards Merle. (Gallier & Strohl), Bowling Green, Ohio	May 31, 1910
Stromquist, Walter Gottfrid. Asst. Engr., State Water Survey, Urbana, Ill.	Dec. 5, 1911
Strong, Sidney Davis. Junior Engr., U. S. Engr. Office, Sault Ste. Marie, Mich.	Nov. 5, 1907
Strout, Gale Stanley. Room 626, First National Bank Bldg., Oakland, Cal.	Mar. 31, 1908
Sun, Taoyuh Clarance. Asst. Engr. on Kirin & Chang Chung R. R., 15 Peking Rd., Shanghai, China	Oct. 4, 1910
Suttle, Clifford Bradley. 43d and Chester Ave., Philadelphia, Pa.	Oct. 30, 1906
Sweetland, Harold Anthony. 9 Orchard Ave., Providence, R. I.	Oct. 5, 1909
Swensson, Otto Jordan. Insp., Board of Water Supply, New York City; Res., 107 Warburton Ave., Yonkers, N. Y.	Nov. 8, 1909
Swett, Everett Harold. Care, U. S. Reclamation Service, Montrose, Colo.	Oct. 1, 1907
Swett, William Claude. Asst. Engr., Ore. Short Line R. R., P. O. Box 51, Pocatello, Idaho	Nov. 1, 1910
Swift, Arthur Cunningham. Engr. and Surv.; Surv., U. S. Engr. Corps, Broad and Monmouth Sts., Red Bank, N. J.	June 30, 1911
Swinton, Roy Stanley. 52 Tennessee St., Manila, Philippine Islands	May 2, 1911
Tappan, Roger. Care, Baring Bros. & Co., Ltd., 8 Bishopsgate St., Within, London, E. C., England	Dec. 3, 1884
Tatum, Robert Lee. U. S. Junior Engr., Box 404, Vicksburg, Miss.	Nov. 8, 1909
Taylor, George Blaney. Engr. with Berlin Constr. Co., Berlin (Res., 136 Black Rock Ave., New Britain), Conn.	May 3, 1910
Taylor, Nelson. 624 South Burlington Ave., Los Angeles, Cal.	Sept. 5, 1911
Teal, Jonathan Ernest. Asst. Engr., Operating Dept., B. & O. R. R., B. & O. Bldg., Baltimore, Md.	June 1, 1909
Tefft, William Wolcott. Constr. Office, Wealthy Ave. Steam Plant, Grand Rapids, Mich.	Mar. 31, 1908
Teichert, Adolph, Jr. Contr., 2401 J St., Sacramento, Cal.	July 1, 1909
Terry, Francis Marion. Address unknown	June 30, 1910
Thayer, Nathaniel Augustine. 420 West 121st St., New York City	April 5, 1910
Thompson, Gordon Saxton. Asst. in Dept. of Mechanics, Rensselaer Polytechnic Inst., 689 Second Ave., Troy, N. Y.	Sept. 5, 1905
Thompson, James Arthur. Levelman, Interborough Rapid Transit Co., 32 Park Pl., New York City	Jan. 2, 1912
Thomson, Fred Morton. H. E. & W. T. Ry., Office of the Supt., Transportation, Houston, Tex.	Oct. 6, 1908
Thomssen, Edgar Louis. Y. M. C. A., Toledo, Ohio	Sept. 5, 1911
Thorne, Howard Sloan. Supt. of Constr. for George F. Mills, 131 West Bancroft St., Toledo, Ohio	Sept 5, 1911
Tiffany, Nathan Newton. Civ. Engr. and Surv.; Mgr., East Hampton Elec. Light Co., East Hampton, N. Y.	June 5, 1906
Tillit, Pedro Ernesto. Care, United Fruit Co., Constr. Dept., Barrios, Guatemala	Oct. 6, 1908
Tillson, Edwin Delevan. Supt., Dodge, Day & Zimmermann, Altoona, Pa.	Mar. 2, 1909
Timberlake, Seth Martin. Asst. Engr., Board of Water Supply, Cornwall-on-Hudson, N. Y.	Mar. 1, 1910
Tingley, Francis. Care, Seybolt Corsa, R. F. D. No. 1, Walden, N. Y.	Jan. 3, 1911
Tirrell, Charles Edwards. Chf. Engr., A. Friederich & Sons Co., 106 Mill St., Rochester, N. Y.	Sept. 4, 1906

	Date of Membership
Todd, Oliver Julian. Chf. Hydrographer on Sierra Water Supply for City of San Francisco, Groveland, Cal.	Aug. 31, 1909
Toll, Asahel Clark. Bayamón, Porto Rico	Mar. 5, 1907
Toll, Roger Wolcott. Asst., Eng. Dept., Denver City Tramway Co., 700 Tramway Bldg., Denver, Colo.	Oct. 5, 1909
Tolles, Frank Clifton. Junior Engr., U. S. Engr. Office, Louisville, Ky.	May 31, 1910
Toms, Jay William. Engr., Industrial Eng. Co., 462 Candler Annex, Atlanta, Ga.	Nov. 30, 1909
Torralbas, Rafael Joaquin. Asst. Div. Engr., Sewerage and Paving Contr. (Res., 38 Prado St.), Havana, Cuba	Nov. 1, 1910
Towle, Foster. Care, U. S. Reclamation Service, St. Ignatius, Mont.	Oct. 30, 1906
Trask, Warren Dudley. 87 Sewall St., Augusta, Me.	Feb. 1, 1910
Trelease, Frank Johnson. Asst. Engr., Corrugated Bar Co., Mutual Life Bldg., Buffalo, N. Y.	May 3, 1910
Trowbridge, Alfred Lockwood. Field Engr., Pacific Gas & Elec. Co., 445 Sutter St., San Francisco, Cal.	Sept. 3, 1907
Trowbridge, Douglas Stanley. Instr. in Eng., New York Univ., Box 75, University Heights, New York City	April 4, 1911
Tufts, William. 56 Dwight St., Boston, Mass.	June 6, 1911
Turner, Arthur Hubesty. Asst. Engr., Southern Ferro-Concrete Co., 344 Equitable Bldg., Atlanta, Ga.	Oct. 3, 1911
Turner, Le Baron. Engr., U. S. Wind Engine & Pump Co., Batavia, Ill.	Sept. 5, 1905
Tyler, Richard Gaines. State Hydrographer, Care, State Levee and Drainage Board, Austin, Tex.	Oct. 6, 1908
Upton, Joseph. 109 Main St., Flushing, N. Y.	Nov. 1, 1910
Vandervoort, Benjamin Franklin. Box 3, Niagara Falls, N. Y.	Mar. 2, 1909
Vandevanter, Elliott. Supt. of Constr., Claiborne, Johnston & Co., 901 Calvert Bldg., Baltimore, Md.	June 6, 1911
van Duyne, Wilmer Charles. Chf. Engr., East Orange & Ampere Land Co., 289 Newfield St., East Orange, N. J.	Sept. 5, 1911
Van Horne, John Russell. 165 Broadway, Room 2611, New York City	Nov. 5, 1907
Vanneman, Arthur Vosbury. (Torrington & Vanneman), Newburg, W. Va.	June 6, 1911
Van Zile, Harry Lee. Pres., Franklin Boiler Works Co., 39 Cortlandt St., New York City	Jan. 6, 1886
Veatch, Nathan Thomas, Jr. Worley & Black, 301 Reliance Bldg., Kansas City, Mo.	Nov. 8, 1909
Villa, Miguel. Engr. in Chg. of Havana Harbor Work for the Ports Co. of Cuba, O'Reilly 41, Havana, Cuba	Oct. 6, 1908
Vogel, John Leonard. Care, Chf. Engr., C. R. R. of N. J., 243 Liberty St., New York City	Nov. 5, 1907
von Blücher, Carl Felix Kill-Mar. Civ. Engr. and Surv. (C. F. H. v. Blücher & Sons), Corpus Christi, Tex.	Oct. 30, 1906
von Geldern, Edward. Engr. of Levee Dist. No. 2, Yuba City, Cal.	May 5, 1908
Wachtel, Louis. Care, Div. Engr.'s Office, Highway Comm., Watertown, N. Y.	Mar. 2, 1909
Waddell, Needham Everett. With Waddell & Harrington, 1012 Baltimore Ave., Kansas City, Mo.	Sept. 1, 1908
Walker, Edward George. 337 Beverley Rd., Hull, England	April 2, 1907
Walker, William Cooper. Asst. Engr., Humphrey Gas Pump Co., 401 S. A. & K. Bldg., Syracuse, N. Y.	Sept. 5, 1911
Wall, Edward Walter. Civ. Eng. Dept., N. Y., N. H. & H. R. R., 409 Union Station, Providence, R. I.	Dec. 6, 1910
Walton, Harry Collins. Asst. Contr. Engr., McClintic-Marshall Constr. Co., 21 Park Row, New York City	Jan. 5, 1909
Ward, Charles Henry, 2d. Middletown, R. I.	Oct. 5, 1909
Ward, Edward Ashton. Designer, Bridge Dept., N. Y. C. & H. R. R. R., New York City	Oct. 5, 1909
Ward, George Merritt. Pres. and Gen. Mgr., George Merritt Ward, Inc., 350 West 58th St., New York City	Nov. 5, 1907
Ward, Roy Elsen. Long Sault Development Co., Massena, N. Y.	May 2, 1911
Ware, Howard Thomas. Asst. Engr., James Stewart & Co., Baldwinsville, N. Y.	Oct. 4, 1910
Warner, Glenn. Fuel Insp., C., H. & D. R. R., Central Union Station, Cincinnati, Ohio	Jan. 4, 1910
Warner, James Madison. 301 Slocum Ave., Syracuse, N. Y.	April 6, 1909
Warnock, William Harold. Asst. Engr., Board of Water Supply, City of New York, 601 West 149th St., New York City	April 4, 1911
Warrack, James Baldwin. State Supt. of Constr., Northern Hospital for the Insane, Sedro Woolley, Wash.	Jan. 3, 1911
Watson, George Linton. Cons. Engr., Engineers' Club, Philadelphia, Pa.	Mar. 6, 1906
Weaver, Earll Chase. Mgr., Clayton Orchards, Ashland, Ore.	Mar. 31, 1908
Weber, Daniel Rishel. Box 54, Provo, Utah	Mar. 1, 1910

	Date of Membership
Webster, Royal Sylvester. Asst. Engr., Havana Cent. R. R., Egido 2, Havana, Cuba	Oct. 6, 1903
Wells, Chester Gordon. Asst. Engr., Ore. Short Line R. R., Box 382, Pocatello, Idaho	June 6, 1911
Wentworth, George Lansing. Care, New York City Board of Water Supply, Hill View Reservoir (Res., 1 Halcyon Pl.), Yonkers, N. Y.	April 6, 1909
West, Edward Hazzard. U. S. Junior Engr., Box 72, Louisville, Ky.	Jan. 2, 1912
Wetherell, Dwight Nelson. 115 North Garrison Ave., Carthage, Mo.	Nov. 1, 1910
Wheatcroft, Henry Belcher, Jr. 438 West 57th St., New York City	June 6, 1911
Whitman, Kilborn, Jr. Asst. Engr., Board of Water Supply of New York City, 523 West 122d St., New York City	Sept. 6, 1910
Whitman, William Satterwhite. Care, Chf. Engr., L. & N. R. R., Louisville, Ky	May 2, 1911
Whittemore, Leslie Clifford. Asst. Engr., Board of Water Supply, New York City, 236 Main St., Poughkeepsie, N. Y.	May 3, 1910
Wigholm, Carl August. 634 Sixtieth St., Oakland, Cal.	Dec. 5, 1911
Wilder, Ellwood Coggeshall. Asst. City and County Engr., 1718 Anapuni St., Honolulu, Hawaii	June 30, 1910
C. Wiley, Hugh Lemuel. Pacific Power & Light Co., Portland, Ore.	April 2, 1907
Wiley, Ralph Benjamin. Asst. Prof. of San. and Hydr. Eng., Purdue Univ., 123 Russell St., West Lafayette, Ind.	Feb. 4, 1908
Wilkins, Homer Jenner. Engr. in Chg., Deep Fork Drainage Dist. No. 1, Chandler, Okla.	Oct. 31, 1911
Willard, William Clyde. 5566 Lawton Ave., Oakland, Cal.	Feb. 4, 1908
Willcomb, George Edward. Chemist in Chg., Albany Filtration Works, 113 North Allen St., Albany, N. Y.	Oct. 30, 1906
Willcox, James DeWitt. 1201 East 16th Ave., Denver, Colo.	Feb. 1, 1910
Williams, Clement Clarence. Asst. Prof. of Civ. Eng., Univ. of Colorado, 955 Tenth St., Boulder, Colo.	June 1, 1909
Williams, Rector Linde. Chf. Engr., Reinforced Concrete Co., 801 Columbia Bldg., St. Louis, Mo.	Sept. 1, 1908
Willis, Albert Jones. Instr. in Civ. Eng., Cooper Union, New York City (Res., 311 Cherokee St., South Bethlehem, Pa.)	June 4, 1907
Wilmot, James. 16 Elgin St., Providence, R. I.	Sept. 1, 1908
Wilmot, Sydney. 416 West 118th St., New York City	Nov. 8, 1909
Wilson, Claude Thomas. 215 West 23d St., New York City	Dec. 5, 1911
Wilson, Rodney Melledge. Chf. Draftsman, Dept. of Mains and Services, Consolidated Gas Co., 124 East 15th St., New York City	May 31, 1910
Wilson, Samuel. 4120 Kingman Boulevard, Des Moines, Iowa	April 3, 1906
Wilson, William West. Care, Canadian Stewart Co., Ltd., Jonquieres, Que., Canada	Dec. 4, 1906
Winans, Lawrence Lewis. Fruitville, Howell Co., Mo.	Nov. 8, 1909
Winchester, Thomas Harrison. Care, Stone & Webster Eng. Corporation, Columbus, Ga.	May 4, 1909
Winsor, Harry Draper. Asst. Engr., Board of Water Supply, City of New York, 511 West 184th St., New York City	Mar. 1, 1910
Wintermute, Ferd Clark. Civ. and Min. Engr. (Young & Wintermute), 410 Second National Bank Bldg, Wilkes-Barre, Pa.	July 1, 1909
Winton, Walter Ferrell. Second Lieut., U. S. A.; Res., 1916 Adelicia Ave., Nashville, Tenn.	Oct. 31, 1911
Wise, Russell Sherwood. 50 Albion St., Passaic, N. J.	April 2, 1907
Wittstein, Herman Lewis. Asst. Engr., Board of Water Supply, New York City; Res., 392 Congress Ave., New Haven, Conn.	Oct. 6, 1908
Wolff, Alfred Daniel, Jr. Draftsman, N. Y. C. & H. R. R. R., 215 West 23d St., New York City	Feb. 28, 1911
Woodruff, Charles William. 420 Henry Bldg., Portland, Ore.	Jan. 4, 1910
Woods, Harland Clark. Univ. of Colorado, Boulder, Colo.	Feb. 28, 1911
Wright, Rene Barber. Civ. and Structural Engr., U. P. R. R., 2608 Ames Ave., Omaha, Nebr.	Aug. 31, 1909
Wright, Thomas Judson, Jr. Asst. in Office of Chf. Engr., Piedmont & Northern Lines, 212 Trust Bldg., Charlotte, N. C.	June 1, 1909
Wygant, Robert Cecil. Asst. to State Engr., Salem, Ore.	Oct. 6, 1908
Yarnell, David Leroy. Asst. Drainage Engr., U. S. Dept. of Agriculture, Drainage Investigations O. E. S., Washington, D. C.	April 5, 1910
Yeo, William Albert. National Eng. Co., 500 Fifth Ave., Room 402, New York City	Oct. 1, 1907
Yost, Howard McClymonds. Massillon, Ohio	June 6, 1911
Young, Oliver Earle. U. S. Junior Engr., R. F. D. No. 1, Lincoln, Ala.	June 6, 1911
Zabriskie, Aaron J. 23 Fifth Ave., New York City	July 1, 1885

Juniors, 804.

FELLOWS

[F. Am. Soc. C. E.]

	Date of Membership
ADAMS, EDWARD DEAN. Chairman, Lehigh Coke Co.; Pres., East Jersey Water Co.; Chairman, Kerbaugh-Empire Co., 71 Broadway, New York City	Mar. 31, 1891
ALBRIGHT, JOHN JOSEPH. Buffalo, N. Y	April 20, 1886
BELKNAP, WILLIAM RICHARDSON. 2d and Washington Sts., Louisville, Ky	May 28, 1872
BLATCHFORD, ELIPHALET W. 1111 La Salle Ave., Chicago, Ill	Feb. 6, 1873
CLARK, EDWARD WHITE. 321 Chestnut St., Philadelphia, Pa	April 8, 1870
COIT, EDWARD WOOLSEY. 2545 Sixth Ave., Los Angeles, Cal	Sept. 20, 1872
DARWIN, HARRY GILBERT. Mgr., Indian Cache Ranch; Vice-Pres., and Gen. Mgr., Waha-Lewiston Land & Water Co. (Res., 402 Prospect Ave.), Lewiston, Idaho	Mar. 22, 1887
DU PONT, BIDERMAN. 808 Broome St., Wilmington, Del	Sept. 5, 1873
EVEREST, CHARLES MARVIN. First Vice-Pres., Vacuum Oil Co., 506 West Ave., Rochester, N. Y	Nov. 1, 1892
FLINT, CHARLES R. Flint & Co., 25 Broad St. (Res., 4 East 36th St.), New York City	June 7, 1876
GREEN, SAMUEL MAGEE. 1235 Wells Bldg., Milwaukee, Wis	Sept. 5, 1888
HILL, JAMES JEROME. Pres., G. N. Ry., St. Paul, Minn	Jan. 10, 1889
HOLMAN, STEPHEN. Swampscott, Mass	June 29, 1872
KIDDLE, ALFRED WATTS. 115 Broadway, New York City	Oct. 3, 1893
MERRITT, GEORGE. Address unknown	May 6, 1870
MEYER, HENRY CODDINGTON. 1 Madison Ave., New York City	Oct. 22, 1885
RICHMOND, HENRY A. 348 Delaware Ave., Buffalo, N. Y	July 7, 1870
STANTON, JOHN ROBERT. 11 William St., New York City	April 4, 1899
WATSON, JAMES. Hopatcong House, Landing, N. J	Dec. 5, 1872
WELTON, NELSON JAMES. Waterbury, Conn	Jan. 20, 1873

Fellows, 20.

SUMMARY OF MEMBERSHIP, FEBRUARY 10th, 1912.

Honorary Members	8
Corresponding Members	2
Members	2 930
Associate Members	2 424
Associates	176
Juniors	804
Fellows	20
Total	6 364

GEOGRAPHICAL LIST

NORTH AMERICA.

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MEMBERS.—***Cananea.***—L. D. Ricketts. ***Chihuahua.***—B. H. Bryant. ***Colima.***—A. P. Herbert, R. H. Vose. ***Culiacan.***—F. E. Butterfield. ***Guanajuato.***—W. H. Puffer. ***Hermosillo.***—A. F. Wrotnowski. ***Mexico.***—F. Adams, M. M. Barragan, J. B. Body, D. Coe, S. Contri, S. J. Fortin, R. Gayol, A. L. Jones, M. Marroquin y Rivera, M. M. Mendiola, J. W. Miles, A. L. Mills, A. Peimbert, G. Beltran y Puga, A. B. Ross, J. Shand, G. H. T. Shaw, E. K. Smoot, H. McG. Taylor. ***Monterey.***—J. E. Garrett, R. Meyer, N. Turner. ***Orizaba.***—S. W. Stacpoole. ***Panindícuaro.***—T. K. Mathewson. ***Rincon Antonio.***—A. M. C. Byers. ***San Blas.***—E. A. H. Tays. ***Santa Fé.***—I. Mathewson. ***Santa Rosalia.***—W. B. Fuller. ***Sombrerete.***—H. L. Heldt. ***Tlahualilo.***—H. W. Potter. ***Vera Cruz.***—R. T. Jordán.

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ALASKA. Total Membership, 1.

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JUNIORS.—***Maxton.***—W. M. Sanger. ***Morenci.***—W. L. Du Moulin. ***Phœnix.***—F. L. Humphrey. ***Yuma.***—G. Schobinger.

ARKANSAS. Total Membership, 17.

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ASSOCIATES.—***Stamps.***—F. W. Green.

JUNIORS.—***Helena.***—N. W. Green.

CALIFORNIA. Total Membership, 389.

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Wolf, E. L. Woodruff. ***San José.***—J. G. McMillan. ***San Rafael.***—D. E. Melliss. ***Santa Barbara.***—J. R. Chapman, J. F. Flagg. ***Santa Clara.***—C. E. Moore. ***Santa Monica.***—O. B. Suhr. ***Saticoy.***—G. C. Power. ***Stanford University.***—J. C. L. Fish, C. D. Marx. ***Surrey.***—De W. L. Reaburn. ***Willits.***—F. G. Somner. ***Willows.***—M. J. Lorraine, D. W. Ross. ***Yuba City.***—G. McMurtry.

ASSOCIATE MEMBERS.—***Alhambra.*** T. B. Downer. ***Alleghany.***—C. W. McMeekin. ***Bakersfield.***—A. T. Parsons, W. F. Whitaker. ***Berkeley.***—G. H. Baldwin, H. R. Church, E. L. Cope, B. A. Etcheverry, F. W. Haselwood, P. Marquand, A. V. Saph, T. B. Sears, E. L. Soulé, G. B. Sturgeon. ***Brown.***—E. J. Davis. ***Chico.***—B. B. Harris, M. C. Polk. ***Colfax.***—W. Egbert. ***Davenport.***—F. Davis. ***Exeter.***—J. H. Crosett. ***Fort McDowell.***—W. A. Clapp. ***Fresno.***—J. S. Bates, C. P. Jensen, W. R. Wheaton. ***Grass Valley.***—A. B. Foote. ***Imperial.***—R. S. Carberry. ***Larkin.***—T. G. Janney. ***Lindsay.***—C. H. Holley. ***Lone Pine.***—O. W. Peterson. ***Los Angeles.***—J. C. Avakian, W. K. Barnard, W. F. Bixby, E. R. Bowen, A. L. Bush, J. C. Clausen, S. V. Z. Cortelyou, J. B. Dawson, H. W. Dennis, F. G. Dessery, E. T. Flaherty, E. J. Gass, J. C Hain, J. B. Harris, C. W. Lawrence, C. H. Lee, C. R. Olberg, J. H. Payne, H. C. Phillips, W. S. Post, W. C. Sawyer, W. D. Smith, A. McC. Strong, W. M. Thomas, O. A. Wait, A. B. White, N. D. Whitman, S. W. Williams, W. Woodard. ***Oakdale.***—A. Swickard. ***Oakland.***—C. E. Beugler, W. S. Farley, W. N. Frickstad, W. C. Howe, J. L. Lee, M. H. Peck, P. Schuyler, G. Wilhelm. ***Ontario.***—C. L. McClelland. ***Palo Alto.***—J. H. Foss, G. M. Herron. ***Pasadena.***—S. J. Van Ornum, F. E. Wilcox. ***Porterville.***—B. Cole. ***Redding.***—C. Maughmer. ***Richmond.***—H. D. Chapman. ***Rocklin.*** R. R. McGregor. ***Sacramento.***—W. E. Burns, H. A. Daae, U. S. Marshall, C. M. Phinney, G. G. Pollock, F. M. Robinson. ***San Diego.***—G. Butler, G. Cromwell, W. J. Gough, T. B. Hunter, J. H. L. Vogt. ***San Francisco.***—G. W. Armitage, D. Ash, M. J. Bartell, F. G. Baum, A. L. Bobbs, G. A. Bos, C. P. Bowie, M. H. Brinkley, H. J. Brunnier, J. O. Burrage, P. L. Bush, H. A. Campbell, E. M. Chadbourne, W. V. Clark, R. G. Clifford, G. J. Couchot, M. R. Daniels, H. M. Daugherty, W. P. Day, H. D. Dewell, R. M. Drake, T. G. Elbury, G. A. M. Elliott, F. H. Fowler, C. E. Gilman, L. S. Griswold, H. L. Haehl, C. R. Hall, H. H. Hall, G. S. Hill, J. G. L. Hopper, W. L. Huber, L. E. Hunt, L. R. Jorgensen, S. A. Jubb, A. Judell, A. Kempkey, A. J. Krafft, W. J. Lightfoot, N. B. Livermore, H. D. McGlashan, A. H. Markwart, O. C. Merrill, L. H. Nishkian, F. J. O'Hara, J. M. O'Hara, J. M. Owens, W. H. Popert, C. I. Rhodes, F. T. Robson, L. S. Rosener, F. O. Shutts, H. W. Swanitz, F. H. Tibbetts, H. C. Vensano, G. W. Wade, J. J. Walsh, F. G. White, J. H. Wise, C. N. Young. ***San Mateo.***—T. J. Jones. ***San Rafael.***—E. N. Prouty. ***Santa Paula.***—A. C. Hardison. ***South Berkeley.***—H. I. Dygert. ***Stanford University.***—N. M. Halcombe. ***Vallejo.***—F. E. Frey. ***Visalia.***—H. H. Holley. ***West Berkeley.***—A. J. Wagner. ***Willows.***—W. G. Davies.

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FELLOWS.—***Los Angeles.***—E. W. Coit.

COLORADO. Total Membership, 90.

MEMBERS.—***Boulder.***—M. S. Ketchum. ***Canon City.***—A. R. Livingston. ***Colorado Springs.***—E. C. van Diest. ***Denver.***—G. G. Anderson, H. W. Baum, J. A. Beeler, L. D. Blauvelt, G. M. Bull, C. W. Comstock, H. W. Cowan, H. S. Crocker, L. B. Curtis, A. L. Fellows, J. E. Field, J. H. Frederickson, M. C. Hinderlider, G. N. Houston, J. B. Hunter, T. W. Jaycox, H. F. Meryweather, G. T. Prince, A. O. Ridgway, H. A. Storrs, R. S. Sumner, D. G. Thomas, J. C. Ulrich, C. D. Vail, E. F. Vincent, R. F. Walter, W. C. Wetherill, T. L. Wilkinson. ***Fort Collins.***—C. R. Hedke. ***Glenwood Springs.***—T. Rosenberg. ***Greeley.***—O. F. Shattuck. ***Holly.***—S. G. Porter. ***La Junta.***—F. M. Bisbee. ***Littleton.***—J. E. Maloney. ***Mack.***—M. W. Cooley. ***Montrose.***—M. P. Paret. ***Paonia.***—W. B. Rittenhouse. ***Salida.***—J. W. Deen. ***San Acacio.***—W. DeW. Waltman.

ASSOCIATE MEMBERS.—***Alamosa.***—C. B. Sampson. ***Denver.***—A. G. Allan, L. E. Bishop, F. C. Carstarphen, B. D. De Weese, W. G. Dow, R. Follansbee, E. C. Jansen, J. Y. Jewett, V. A. Kauffman, C. S. Lambie, T. W. Norcross, E. N. Sheffield, A. Spengler, M. E. Witham, J. Y. Work. ***Fort Collins.***—B. G. Coy, L. R. Stockman. ***Golden.***—W. F. Allison. ***Grand Junction.***—S. O. Harper, J. H. Miner. ***Greeley.***—J. R. Wortham. ***Littleton.***—T. S. Shepperd. ***Montrose.***—J. H. Fertig. ***Norwood.***—J. L. Hershey. ***Penrose.***—W. Holbrook. ***Pueblo.***—D. E. Helvern, J. E. Shoemaker, A. A. Weiland. ***Trinidad.***—W. R. Lewis. ***Vallery.***—W. P. Hufschmidt.

JUNIORS.—***Blanca.***—C. H. W. Smith. ***Boulder.***—C. M. Duff, C. C. Williams, H. C. Woods. ***Colorado Springs.***—W. A. Bartlett. ***Cripple Creek.***—A. L. B. Moser. ***Denver.***—H. A. Appel, T. Bartholomew, L. R. Hinman, M. K. Jordan, G. R. Ogier, G. W. Reese, R. W. Toll, J. DeW. Willcox ***Montrose.***—E. H. Swett. ***Pueblo.***—W. J. Burton. ***Telluride.***—T. Lindsley.

CONNECTICUT. Total Membership, 97.

MEMBERS.—*Berlin.*—D. E. Bradley, C. F. Chase. *Bridgeport.*—T. B. Ford. *Derby.*—D. S. Brinsmade. *East Haddam.*—E. W. Bush. *Hartford.*—G. M. Bond, H. R. Buck, R. N. Clark, F. L. Ford, R. F. Gadd, J. T. Henderson, T. H. Loomis, T. H. McKenzie, C. M. Saville, H. Souther. *New Britain.*—C. M. Jarvis. *New Haven.*—C. Blakeslee, L. J. Carmalt, A. J. Du Bois, W. R. Dunham, Jr., F. J. Easterbrook, C. C. Elwell, C. A. Ferry, H. H. Gladding, C. R. Harte, A. B. Hill, C. W. Kelly, E. W. Lewis, E. H. McHenry, E. E. Minor, W. H. Moore, C. H. Nichols, J. A. Norcross, H. L. Ripley, T. C. B. Snell, G. E. Verrill. *New London.*—F. W. LaForge. *Noroton.*—A. H. Renshaw. *Norwalk.*—R. Van Buren. *Norwich.*—S. B. Palmer, C. H. Preston. *Stamford.*—W. A. Aycrigg, H. A. Parsons. *Waterbury.*—R. A. Cairns, C. H. Preston, Jr. *West Haven.*—E. Gagel.

ASSOCIATE MEMBERS.—*Berlin.*—C. Derrick. *Botsford.*—P. R. Leete. *Bridgeport.*—S. P. Senior, R. F. Stoddard, A. H. Terry. *Derby.*—D. E. Brinsmade. *East Hartford.*—A. S. Brainard. *Hartford.*—A. B. Alderson, W. J. Backes, L. H. Burt, A. H. Greenwood, R. C. Noerr, E. M. Peck, P. Sheldon, R. H. Stearns, E. W. Wiggin. *Meriden.*—C. L. Cole. *New Britain.*—A. W. Bacon, W. H. Hall. *New Hartford.*—H. W. Horne. *New Haven.*—C. M. Blair, E. W. Crawley, H. Miller, J. P. Wadhams. *New London.*—H. L. Dunn, A. E. Waldron. *Norwich.*—L. M. Young. *Old Lyme.*—H. T. Griswold. *Stamford.*—R. DeW. Havens. *Thomaston.*—C. W. Eddy. *Waterbury.*—W. T. Spencer. *West Hartford.*—W. E. Johnson. *West Haven.*—G. R. Johnson.

ASSOCIATES.—*Litchfield.*—D. G. Ambler. *Stamford.*—G. A. Weber. *Waterbury.*—M. A. O. Stilson.

JUNIORS.—*Berlin.*—G. B. Taylor. *Bridgeport.*—H. L. Eames, H. A. Seeley. *Hartford.*—W. S. Brewer, R. B. Stanton, Jr. *New Haven.*—F. W. Amadon, R. F. Roberts, H. L. Wittstein. *New London.*—E. L. Chandler. *Stamford.*—A. S. Lynch, R. G. Rice, G. H. Stadel. *Suffield.*—R. E. Spaulding. *Waterville.*—I. W. Patterson.

FELLOWS.—*Waterbury.*—N. J. Welton.

DELAWARE. Total Membership, 17.

MEMBERS.—*Delaware City.*—F. C. Warner. *Edge Moor.*—E. Mowlds. *New Castle.*—A. Bryson. *Newark.*—J. R. Maxwell. *Wilmington.*—W. H. Fenn, T. C. Hatton.

ASSOCIATE MEMBERS.—*Wilmington.*—H. E. Breed, W. A. Heindle, E. R. Mack, H. L. Maier, A. J. Taylor.

ASSOCIATES.—*Wilmington.*—A. J. Moxham.

JUNIORS.—*Wilmington.*—W. J. Horrigan, J. A. Kienle, W. G. Rommel, P. F. Rossell.

FELLOWS.—*Wilmington.*—B. du Pont.

DISTRICT OF COLUMBIA. Total Membership, 117.

HONORARY MEMBERS.—*Washington.*—A. Mackenzie.

MEMBERS.—*Washington.*—W. H. Allen, F. L. Averill, T. C. J. Baily, Jr., R. E. Bakenhus, E. C. Barnard, H. A. Belden, J. Biddle, W. H. Bixby, F. C. Boggs, E. Burr, D. S. Carll, F. T. Chambers, W. D. Connor, S. Cosby, W. Crozier, A. C. Cunningham, A. P. Davis, W. F. Dennis, E. M. Douglas, E. J. Duffies, C. G. Elliott, M. T. Endicott, O. H. Ernst, O. B. French, F. Freyhold, A. A. Fries, B. R. Green, W. C. Gunnell, P. C. Hains, J. H. Hanna, E. D. Hardy, W. W. Harts, R. C. Hollyday, D. J. Howell, R. L. Hoxie, J. C. Hoyt, C. B. Hunt, W. V. Judson, M. O. Leighton, M. W. Lewis, D. W. Lum, D. E. McComb, E. W. McCormack, W. A. McFarland, C. A. McKenney, R. B. Marshall, C. A. Miner, A. T. Mosman, D. W. Murphy, F. H. Newell, G. L. Nicolson, L. W. Page, W. N. Page, A. E. Phillips, F. C. Prindle, G. R. Putnam, P. L. Reed, P. D. Sargent, H. R. Stanford, F. Sutton, S. Tatum, H. Taylor, F. Thompson, O. H. Tittmann, A. H. Weber.

ASSOCIATE MEMBERS.—*Washington.*—R. E. Adams, E. C. Bebb, R. Coltman, Jr., J. S. Conway, G. R. Davis, H. Davis, L. S. Doten, J. R. Downman, W. A. E. Doying, C. F. Eberly, M. O. Eldridge, J. B. Gordon, U. S Grant, 3d, N. C. Grover, E. C. Heald, J. P. Healy, N. H. Heck, E. A. Hill, L. M. Holt, H. B. Hurlbut, A. B. Ilsley, G. R. Jones, G. K. Larrison, W. C. Lyon, T. W. Marshall, F. E. Matthes, O. A. Mechlin, F. K. Merriman, H. Munroe, R. Y. Patterson, T. J. Powell, H. A. Pressey, M. S. Rich, T. Riggs, Jr., S. D. Rockenbach, C. L. Sadler, H. Stabler, F. C. Starr, H. Stidham, S. S. Storer, C. H. Tompkins, C. G. Tudor, W. McG. Wallace, F. R. Weller.

ASSOCIATES.—*Washington.*—A. S. Cushman, E. C. Eckel, G. Pinchot.

JUNIORS.—*Washington.*—R. McL. Bowman, F. C. Hilder, F. R. Nitchie, D. L. Yarnell.

FLORIDA. Total Membership, 41.

MEMBERS.—*Bartow.*—M. A. Waldo. *Caryville.*—C. B. Wilson. *Jacksonville.*—J. M. Braxton, F. W. Bruce, A. F. Harley, W. N. McDonald, F. Phillips, J. W. Sackett. *Key West.*—F. O. Maxson. *Marathon.*—R. W. Carter, W. J. Krome. *Ostega.*—J. H. Bacon. *Pensacola.*—G. H. Maurice, G. Rommel, Jr. *St. Augustine.*—L. R. McLain. *Tampa.*—W. [illegible] Caldwell, B. Thompson.

ASSOCIATE MEMBERS.—***Bartow.*** A. Schneider. ***Fort Lauderdale.***—R. F. Ensey. ***Islamorada.*** P. L. Wilson. ***Jacksonville.*** W. P. Darwin, J. T. Land, H. G. Perring. ***Key West.*** C. E. Brown. ***Lakeland.***—C. F. Brush. ***Orlando.***—G. R. Ramsey. ***Punta Gorda.***—J. R. Aiken head. ***St. Augustine.***—R. H. Martin. ***St. Petersburg.***—F. E Estes. ***Tallahassee.***—J. E. Craig. ***Tampa.***—W. W. Fineren. ***West Palm Beach.***—O. Randolph.

JUNIORS. –***Fort Pierce.***—J. G. Moore. ***Jacksonville.*** –H. I. Snyder. ***Key West.***—C. G. Bailey, J. R. Baldridge. ***Lakeland.***—H. D. Mendenhall. ***Long Key.*** –J. R. Brooks. ***Pensacola.***—W. S. Moore. ***Port St. Joe.***—G. E. Dunan. ***St. Augustine.***—F. S. Parrigin.

GEORGIA. Total Membership, 48.

MEMBERS.—***Americus.***—G. M. Eldridge. ***Athens.*** J. W. Barnett, C. M. Strahan. ***Atlanta.***—A. Bonnyman, R. M. Clayton, P. A. Dallis, B. M. Hall, J. N. Hazlehurst, A. Pew, J. Ruddle. ***Augusta.***—N. Wingfield. ***Columbus.***—B. H. Hardaway. ***Macon.***—C. A. Caldwell, D. B. Dunn. ***Rome.***—D. M. Andrews, S. McC. Young. ***Savannah.***—G. M. Gadsden, H. S. Jaudon, J. de B. Kops, E. M. Rhett. ***Tallulah Falls.***—M. Blanchard.

ASSOCIATE MEMBERS.—***Americus.***—B. H. Klyce. ***Athens.***—J. C. Koch. ***Atlanta.***—T. P. Branch, A. V. Gude, Jr., W. E. Hall, A. P. Haney, W. A. Hansell, C. W. Murray, P. H. Norcross, H. T. Poe, Jr., A. P. Robinson, G. R. Solomon, W. C. Spiker. ***Augusta.***—J. D. Twiggs, Jr. ***Brunswick.***—W. C. S. Lemen, J. L. Zachry. ***Columbus.***—G. F. Harley. ***Norcross.***—J. A. Griffin. ***Rome.***—K. Lindsey. ***Savannah.***—R. S. King.

JUNIORS.—***Atlanta.***—K. W. Brittain, J. W. Toms, A. H. Turner. ***Augusta.***—E. C. Garvin, T. H. H. Harrod, E. G. Smith. ***Columbus.***—T. H. Winchester.

HAWAII. Total Membership, 19.

MEMBERS.—***Hilo.***—H. K. Bishop, C. H. Kluegel. ***Honolulu.*** -R. Quinn, F. B. Smith, J. T. Taylor, W. P. Wooten. ***Kahului.***—J. N. S. Williams. ***Pearl Harbor.***—E. R. Gayler.

ASSOCIATE MEMBERS. ***Hilo.***—E. A. Southworth. ***Honolulu.***—A. E. Arledge, J. S. Goodell, H. M. Goodman, A. R. Keller, W. F. Martin, E. Schmitt, A. C. Wheeler.

JUNIORS.—***Honolulu.***—J. W. Caldwell, E. C. Wilder. ***Kahului.***—J. C. Foss, Jr.

IDAHO. Total Membership, 51.

MEMBERS.—***Boise.***—F. C. Horn, C. H. Paul, J. Stephenson, Jr., G. L. Swendsen, F. E. Weymouth, A. J. Wiley. ***Caldwell.***—J. T. Burke. ***Downey.***—J. Ware. ***Grangeville.***—W. H. Hill. ***Nampa.***—J. H. Smith. ***Pocatello.***—W. R. Armstrong, J. P. Congdon. ***Rupert.***—R. S. Fessenden. ***St. Maries.*** –M. S. Parker. ***Spirit Lake.***—W. C. Smith.

ASSOCIATE MEMBERS.—***Arrowrock.***—A. B. Mayhew. ***Boise.***—G. C. Baldwin, G. H. Bliss, F. M. Carhart, W. E. Cory, F. T. Crowe, W. F. Day, C. C. Fisher, A. M. Gilbert, C. L. Huff, R. J. Newell, J. L. Savage, C. B. Smith, C. Spearman, W. G. Swendsen. ***Caldwell.***—H. S. Williams. ***Gooding.***—E. St. C. Smith. ***Hollister.***—J. B. Stocking. ***Jerome.***—C. E. Carter, ***New Meadows.***—L. Highley. ***Parma.***—W. Ward. ***Pocatello.*** –J. N. McLoughlin, H. A. Roberts. ***Richfield.***—M. R. Kays, I. W. McConnell. ***Rupert.***—P. M. Fogg. ***Twin Falls.***—S. D. Clinton, R. S. Cookinham.

JUNIORS.—***Arco.***—J. T. Henderson. ***Boise.***—L. Crandall, J. S. Longwell. ***Moscow.***—D. B. Steinman. ***Pocatello.***—W. C. Swett, C. G. Wells. ***Wendell.***—R. S. Larimer.

FELLOWS.—***Lewiston.***—H. G. Darwin.

ILLINOIS. Total Membership, 307.

MEMBERS. ·***Alton.***—E. A. Hermann, T. C. Moorshead. ***Batavia.***—W. H. Finley. ***Chicago.***—A. Allen, J. W. Alvord, W. E. Angier, W. C. Armstrong, B. J. Arnold, S. G. Artingstall, F. H. Avery, A. S. Baldwin, C. B. Ball, W. D. Barber, W. T. Barnes, H. E. Bartlett, O. Bates, J. B. Berry, C. E. Billin, G. H. Binkley, W. L. Breckinridge, G. H. Bremner, D. J. Brumley, J. Brunner, C. B. Burdick, H. J. Burt, H. M. Byllesby, W. J. Cahill, W. M. Camp, E. C. Carter, C. H Cartlidge, W. A. Christian, G. B. Christie, T. W. Clayton, J. A. Cole, T. L. Condron, L. E. Cooley, W. L. Cowles, W. W. Curtis, C. R. Dart, F. E. Davidson, F. A. Delano, C. M. Denise, G. Devin, De C. Dunlap, H. N. Elmer, J. W. Emig, J. E. Ericson, L. H. Evans, J. M. Ewen, S. M. Felton, C. R. Fickes, H. B. Fleming, R. Forsyth, L. C. Fritch, J. R. Furman, J. L. Fyfe, R. E. Gaut, R. L. Gifford, H. P. Gillette, H. H. Hadsall, J. C. Hallsted, J. N. Hatch, C. D. Hill, J. B. Hittell, G. T. Horton, H. E. Horton, C. W. Hotchkiss, L. J. Hotchkiss, C. P. Howard, W. A. Hoyt, W. M. Hughes, R. W. Hunt, W. B. Jackson, C. L. Keller, E. H. Lawrence, E. H. Lee, C. M. Leonard, F. J. Llewellyn, J. Lowe, C. F. Loweth, W. A. Lydon, E. McCullough, H. McKay, W. W. Marr, E. D. Martin, A. J. Mason, L. J. Mensch, R. Modjeski, J. E. Moore, E. S. Nethercut, A. W. Newton, L. A. Nichols, W. R. Patterson, J. W. Pearl, W. H. Penfield, E. T. Perkins, A. E. Phillips, A. V. Powell, T. F. Quilty, I. Randolph, W. Raster, A. F. Reichmann, A. A. Righter, L. E Ritter, S. S. Roberts, A. F. Robinson, W. A. Rogers, W. H. Rosencrans, H. R. Safford, G. F. Samuel, E. C. Shankland, R. M. Shankland, E. L. Shaw, Le R. K. Sherman, H. J. Slifer, D. Sloan, S. T. Smetters, G. W. Smith, R. C. Smith, W. R. Smith, I. F. Stern, W. B. Storey, Jr., O. E. Strehlow, C. L. Strobel, M. K. Trumbull, F. G. Vent, W. T. Walker, H. U. Wallace, G. Weston, A. J. Whart, H. F. White, C. S. Williamson, F. R. Williamson, P. Willis, E. B. Wilson, B. E. Winslow, G. M.

Wisner, E. N. Wood, A. W. Woodman, A. Ziesing, G. A. Zinn. ***East St. Louis.***—T. N. Jacob, W. A. Thompson. ***Edwardsville.***—C. A. Sheppard. ***Evanston.***—W. H. Burger, J. F. Hayford, C. J. Morse. ***Joliet.***—F. C. H. Arentz. ***Litchfield.***—A. G. Kleinbeck. ***Naval Station.***—C. D. Thurber. ***Peoria.*** J. A. Harman, D. H. Maury, S. M. Russell. ***Rock Falls.***—H. E. Reeves. ***Rock Island.***—J. B. Bassett, C. Keller, R. Monroe, A. L. Richards. ***Springfield.***—F. H. Hamilton, A. N. Johnson. ***Sterling.***—A. O. Rowse, L. L. Wheeler. ***Urbana.***—I. O. Baker, A. N. Talbot. ***Western Springs.***—J. Nichol.

ASSOCIATE MEMBERS.—***Barrington.***—W. I. Martin. ***Bloomington.***—J. G. Melluish. ***Chicago.***—J. S. Adey, F. W. Adgate, W. H. Alderson, J. L. Allen, W. G. Arn, J. Arrington, W. E. Belcher, G. S. Bergendahl, J. C. Blaylock, I. C. Brower, R. M. Brown, J. E. Cahill, F. D. Chase, F. R. Coates, O. F. Cole, W. T. Colman, F. L. Copeland, J. W. Cornell, A. A. Cother, J. E. B Dahlin, S. Dean, W. W. DeBerard, J. T. Dickerson, H. S. Doyle, E. B. Espenshade, J. C. Fruit, E. J. Fucik, L. Garbi, Jr., D. B. A. Graham, W. F. Graves, J. A. Green, P. E. Green, T. D. Gregg, E. O. Greifenhagen, H. E. Grimm, G. E. Gustafson, T. L. D. Hadwen, E. McK. Hagar, H. R. Harbeck, F. C. Harper, W S. Hazelton, L. L. Hunter, W. E. Ingram, M. Johnson, F. R. Judd, H. B. Kirkpatrick, F. B. Knight, J. B. Koon, R. E. Koon, A. S. Lewis, S. B. Lincoln, J. W. Ludlow, J. L. McConnell, H. J. McDargh, R. J. Middleton, F. E. Morrow, J. E. Murphy, A. T. North, J. Paige, L. Pearse, C. W. Petersen, L. E. Philbrook, T. C. Phillips, C. L. Post, H. P. Ramey, F. A. Randall, R. I. Randolph, E. H. Ravenscroft, J. W. Reid, H. B. Sauerman, W. B. Saunders, H. L. Sawyer, F. N. Spencer, J. G. Spielman, H. L. Stevens, J. W. Stromberg, W. A. Theodorson, G. L. Thon, E. E. R. Tratman, W. P. Tunstall, S. Van Pelt, G. S. Walter, E. Walther, H. P. Warren, J. V. Wescott, O. J. West, R. A. Widdicombe, A. Yappen. ***Depue.***—W. J. Boucher. ***East St. Louis.***—R. L. Murphy. ***Fisher.***—T. S. Hewerdine. ***Granite City.***—N. A. Melick. ***Kewanee.***—J. E. Kemp. ***Morgan Park.***—R. H. Burke. ***Ottawa.***—C. F. Brenn. ***Rock Island.***—M. H. Kanary. ***Shelbyville.***—C. E. Chester. ***Springfield.***—H. E. Bilger, C. Older. ***Urbana.***—F. O. Dufour, N. B. Garver, P. Hansen, J. B. Hutchings, Jr., C. W. Malcolm.

ASSOCIATES.—***Chicago.***—R. E. Belknap, C. M. Foster, E. Haupt, W. J. C. Kenyon, J. D. Newton, L. P. Ryan, G. H. Scribner, Jr., W. J. Vanderkloot, J. H. Warder.

JUNIORS.—***Batavia.***—Le B. Turner. ***Champaign.***—J. R. Scott, Jr. ***Charleston.***—S. McCrory. ***Chicago.***—B. Borland, G. Bryan, Jr., O. B. Carlisle, S. G. Cutler, D. M. Dodds, R. S. Gram, J. R. Hall, H. W. Henes, C. Huth, C. B. Lewis, G. F. Maglott, D. H. Maxwell, G. H. Paine, H. G. Raschbacher, R. M. Roberg, R. G. Shankland, G. W. Smith, C. S. Stewart. ***Springfield.***—W. R. Robinson. ***Sullivan.***—W. W. Huff. ***Urbana.***—D. A. Abrams, W. G. Stromquist. ***Winnetka.***—S. A. Greeley.

FELLOWS.—***Chicago.***—E. W. Blatchford.

INDIANA. Total Membership, 40.

MEMBERS.—***Gary.***—F. W. Dencer. ***Indianapolis.***—W. G. Atwood, C. C. Brown, M. M. Defrees, J. W. Moore. ***Michigan City.***—C. Schroeder. ***Richmond.***—S. W. Hayes. ***South Bend.***—F. A. Bryan, A. J. Hammond, W. S. Moore. ***Terre Haute.***—M. A. Howe.

ASSOCIATE MEMBERS.—***Anderson.***—L. A. Mitchell. ***Bedford.***—G. A. Haynes. ***Elkhart.***—S. H. Scharschmidt. ***Evansville.***—C. E. Smith. ***Gary.***—D. O. Carr, J. H. Cross, A. P. Melton. ***Hammond.***—M. E. Shire. ***Indianapolis.***—A. C. Harrington, A. R. Holliday, W. H. Insley, E. C. Strathmann. ***Lafayette.***—H. O. Garman, W. K. Hatt, R. L. Sackett. ***La Porte.***—E. C. Shoecraft. ***Logansport.***—H. W. Brown, H. F. Coleman, E. B. Taylor, Jr. ***Terre Haute.***—J. W. Ijams.

ASSOCIATES.—***Indianapolis.***—H. E. Jordan. ***West Lafayette.***—A. P. Poorman, A. Smith.

JUNIORS.—***Gary.***—C. L. Dimmler. ***Indianapolis.***—J. A. Craven, J. E. Hall. ***Montmorenci.***—G. E. Halstead. ***Valparaiso.***—H. P. McKean. ***West Lafayette.***—R. B. Wiley.

IOWA. Total Membership, 35.

MEMBERS.—***Ames.***—A. Marston. ***Burlington.***—F. D. H. Lawlor. ***Davenport.***—G. H. Boynton, C. Francis, W. H. Kimball. ***Des Moines.***—R. T. Hartman, J. B. Marsh. ***Dubuque.***—H. W. Baker. ***Fort Dodge.***—L. A. Downs. ***Iowa City.***—W. G. Raymond. ***Keokuk.***—H. L. Cooper, M. Meigs, B. H. Parsons. ***Sioux City.***—M. J. Henoch.

ASSOCIATE MEMBERS.—***Ames.***—H. C Ford, H. W. Gray, E. E. King, J. E. Kirkman. ***Clinton.***—R. C. Hart. ***Des Moines.***—P. Beer, C. H. Fuller, L. Goodman, G. W. Koss, J. E. Van Liew. ***Iowa City.***—B. J. Lambert. ***Keokuk.***—A. A. Northrop. ***Sioux City.***—P. D. Cook.

JUNIORS.—***Davenport.***—G. H. Mack. ***Des Moines.***—M. DeM. Gates, C. Millard, S. Wilson. ***Hartford.***—R. W. Brooks. ***Iowa City.***—E. A. Dow, H. B. Smith. ***Sioux City.***—K. C. Gaynor.

KANSAS. Total Membership, 35.

MEMBERS.—***Atchison.***—F. Giddings. ***Fort Leavenworth.***—M. L. Walker. ***Lawrence.***—B. J. Dalton, F. O. Marvin. ***Leavenworth.***—E. H. Connor, W. H. Jones, G. W. Vaughn. ***Topeka.***—C. F. W. Felt, E. W. Grant, C. A. Morse, A. A. Robinson, C. C. Witt.

ASSOCIATE MEMBERS.—***Atchison.***—H. E. Boardman. ***Lawrence.***—E. H. Dunmire, W. C. Hoad, H. A. Rice. ***Leavenworth.***—E. H. Barkmann, J. O'Neil, A. Stellhorn. ***Manhattan.***—C. M. Buck, L. E. Conrad, W. S. Gearhart. ***Newton.***—O. Moorshead. ***Pittsburg.***—L. E. Curfman. ***Topeka.***—R. Emerson, J. de N. Macomb, Jr., L. B. Smith, T. J. Strickler, A. M. Vance, J. Weidel, A. R. Young.

ASSOCIATES.—***Iola.***—H. Struckmann.

JUNIORS.—***Fort Leavenworth.***—S. C. Godfrey. ***Leavenworth.***—O. W. J. Anschuetz. ***Morrowville.***—S. A. McWilliams.

KENTUCKY. Total Membership, 55.

MEMBERS.—***Columbus.***—A. T. Sabin. ***Lexington.***—W. D. Pickett. ***Louisa.***—L. S. Johnson. ***Louisville.***—W. C. Brohm, W. H. Courtenay, S. F. Crecelius, J. L. Frazier, W. Gazlay, W. E. Hutchings, J. M. Johnson, E. E. Kuersteiner, T. A. Leisen, R. Montfort, M. Morris, J. C. Murphy, J. H. Peyton, G. W. Shaw, J. E. Willoughby, E. Zarbell. ***Middlesboro.***—W. E. Gunn. ***Newport.***—W. L. Glazier. ***St. Matthews.***—R. Fink. ***Woburn.***—P. W. Early.

ASSOCIATE MEMBERS.—***Ashland.***—S. Sims. ***Covington.***—E. Gray, Jr., F. H. Haskell. ***Frankfort.***—H. G. McCormick. ***Fulton.***—O. T. Dunn. ***Hazard.***—G. H. Justice, J. L. Morrison. ***Lexington.***—R. B. Hayes. ***Louisville.***—F. A. Busse, M. Elliott, W. D. Gray, L. W. Hancock, J. J. Kingman, F. I. Louckes, W. N. Morrill, J. B. Wilson. ***Newport.***—A. H. Horton, C. A. Riggs. ***Paducah.***—S. A. Miller. ***Palace.***—J. S. Butler.

ASSOCIATES.—***Jenkins.***—J. V. Howe. ***Louisville.***—J. B. Speed.

JUNIORS.—***Jenkins.***—W. H. Dunlap. ***Louisville.***—F. E. Hayes, Jr., A. A. Krieger, H. G. Riblet, W. P. Stewart, F. C. Tolles, E. H. West, W. S. Whitman. ***Newport.***—P. S. Monk.

FELLOWS.—***Louisville.***—W. R. Belknap.

LOUISIANA. Total Membership, 40.

MEMBERS.—***Alexandria.***—C. C. Crew, I. W. Sylvester. ***Baton Rouge.***—M. P. Robertson. ***New Orleans.***—L. H. Beach, A. C. Bell, A. L. Black, J. F. Coleman, R. L. Crump, G. McC. Derby, C. Donovan, G. G. Earl, J. T. Eastwood, W. B. Gregory, W. J. Hardee, B. M. Harrod, J. C. Haugh, F. M. Kerr, W. E. Knobloch, S. F. Lewis, A. Perrilliat, A. Raymond, A. M. Shaw, W. B. Wright.

ASSOCIATE MEMBERS.—***Bogalusa.***—W. S. Hanley, C. R. Howard. ***Boyce.***—G. W. Hillman. ***Burrwood.***—J. B. Lindhé. ***Clinton.***—F. D. Nash. ***New Iberia.***—H. J. Cox, R. J. Lockwood. ***New Orleans.***—W. C. Barton, A. M. N. Blamphin, L. C. W. Datz, E. L. Jahncke, C. Johnson, C. W. J. Neville, W. H. Nicol, W. B. Smith, Jr.

JUNIORS.—***Burrwood.***—F. D. Cefalu. ***Sulphur.***—W. A. Buell.

MAINE. Total Membership, 28.

MEMBERS.—***Augusta.***—C. C. Babb, H. F. Hill. ***Bangor.***—P. H. Coombs, G. H. Hamlin. ***Gardiner.***—F. Danforth. ***Houlton.***—M. Burpee. ***Lewiston.***—W. H. Sawyer. ***Madison.***—C. S. Humphreys. ***Portland.***—H. W. Hobbs, E. C. Jordan. ***Rockland.***—O. H. Tripp. ***Rumford.***—C. A. Mixer. ***South Harpswell.***—R. E. Peary.

ASSOCIATE MEMBERS.—***Bangor.***—P. D. Simpson. ***Fort Fairfield.***—H. P. Hoyt. ***Houlton.***—L. B. Lincoln, P. C. Newbegin. ***Millinocket.***—F. C. Bowler. ***Monson.***—E. Y. Allen. ***Orono.***—H. S. Boardman. ***Portland.***—C. C. Derby, W. H. Norris, H. H. Robinson. ***Searsport.***—J. H. Duncan. ***Waterville.***—F. H. Mason, E. C. Wilson.

JUNIORS.—***Augusta.***—W. D. Trask. ***Woodfords.***—A. B. Green.

MARYLAND. Total Membership, 78.

MEMBERS.—***Baltimore.***—P. A. Beatty, A. M. Brosius, H. D. Bush, M. Cohen, W. W. Crosby, E. D. Cummings, J. S. Doyle, W. R. Edwards, B. T. Fendall, H. Fox, J. E. Greiner, F. H. Hambleton, G. R. Harlow, B. P. Harrison, C. W. Hendrick, J. M. Hood, Jr., W. D. Janney, F. A. Kummer, O. F. Lackey, H. A. Lane, M. A. Long, T. D. Pitts, A. M. Quick, L. F. Smith, W. F. Strouse, F. L. Stuart, H. R. Talcott, A. W. Thompson, W. D. Uhler, E. B. Whitman, F. C. Wolfe. ***Catonsville.***—G. B. Hazlehurst. ***Darlington.***—J. H. Harlow. ***Eccleston.***—J. Fisher. ***Hagerstown.***—J. B. Ferguson. ***Towson.***—H. G. Shirley.

ASSOCIATE MEMBERS.—***Baltimore.***—R. N. Begien, R. L. Burwell, R. L. Chamberlaine, L. Dorsey, W. H. Dorsey, J. H. Harlow, Jr., A. H. Hartman, A. H. Krone, E. G. Lane, P. G. Lang, Jr., E. C. Lawrence, C. W. Lush, J. N. Mackall, G. C. Saunders, E. Sudler, H. A. Warren, G. W. C. Whiting, J. L. Wickes. ***Chestertown.***—M. deK. Smith, Jr. ***Cumberland.***—P. B. Boude, G. D. Brooke, C. P. McCausland, H. Rittenhouse. ***Denton.***—H. A. Paine. ***Easton.***—E. G. Kastenhuber, Jr. ***Westport.***—I. O. Harper.

ASSOCIATES.—***Baltimore.***—W. A. Polk.

JUNIORS.—***Annapolis.***—E. T. Hayman. ***Baltimore.***—I. Behrman, L. Bernstein, F. W. Caspari, L. Chevalier, F. W. McKinney, W. W. Pagon, H. S. Regester, Jr., R. L. Reimann-Hansen, V. R. P. Saxe, J. E. Teal, E. Vandevanter. ***Hagerstown.***—R. W. Parlin. ***Loch Raven.***—J. K. Flick. ***Salisbury.***—L. E. Perry.

MASSACHUSETTS. Total Membership, 315.

HONORARY MEMBERS.—***Lowell.***—H. F. Mills.

MEMBERS.—***Amherst.***—J. E. Ostrander. ***Auburndale.***—W. P. Snow. ***Beverly.***—T. A. Appleton. ***Boston.***—F. V. Abbot, H. S. Adams, C. E. Alderman, C. F. Allen, N. F. Ambursen, H. B. Andrews, T. Appleton, T. Aspinwall, W. M. Bailey, F. A. Barbour, H. K. Barrows, B. A. Behrend, D. Brackett, E. W. Branch, G. H. Brazer, C. B. Breed, F. Brooks, M. F. Brown, W. M. Brown, A. F. Burton, M. M. Cannon, H. H. Carter, C. J. Carven, A. S. Cheever, S. Child, W. L. Church, E. C. Clarke, A. B. Corthell, F. S. Curtis, H. C. Daggett, F. S. Darling, R. B. Davis, A. W. Dean, E. S. Dorr, H. P. Eddy, C. Eldridge, G. C. Emerson, F. H. Fay, R. R. Felton, J. N. Ferguson, W. E. Foss, F. L. Fuller, X. H. Goodnough, B. W. Guppy, W. H. Ham, G. E. Harkness, E. Harrington, H. C. Hartwell, T. T. H. Harwood, H. W. Hayes, C. H. Herrick, F. W. Hodgdon, C. J. Hogue, E. W. Howe, D. C. Jackson, W. H. Jaques, W. S. Johnson, F. C. Kimball, G. A. Kimball, H. S. Kimball, E. N. Lake, J. A. Leonard, W. W. Lewis, H. V. Macksey, F. A. McInnes, C. T. Main, L. B. Manley, W. Martin, L. Metcalf, E. F. Miller, H. A. Miller, W. N. Patten, E. E. Pettee, F. C. Pillsbury, A. L. Plimpton, D. Porter, J. R. Rablin, I. Rich, J. W. Rollins, Jr., W. Rotch, L. K. Rourke, R. A. Shailer, F. E. Shedd, C. W. Sherman, E. C. Sherman, F. A. Snow, J. P. Snow, C. M. Spofford, F. P. Stearns, J. H. Sullivan, L. A. Taylor, S. E. Tinkham, E. A. Tucker, E. K. Turner, L. C. Wason, W. Watson, De W. C. Webb, R. S. Weston, B. T. Wheeler, W. Wheeler, F. O. Whitney, H. B. Wood, C. J. H. Woodbury, J. R. Worcester. ***Brookline.***—H. B. Burley, W. H. Chadbourn, Jr., D. FitzGerald, A. H. French, H. Ropes, C. R. Suter. ***Cambridge.***—W. L. Butcher, H. J. Hughes, L. J. Johnson, E. D. Leavitt, J. C. Moses, J. C. Scorgie, G. F. Swain. ***Chelsea.***—W. E. McClintock. ***Dorchester.***—A. H. Morrill, G. S. Morrill, J. E. Palmer, L. L. Street. ***Fall River.***—R. H. Beattie, B. T. Buffinton, H. Lothrop, A. Wolstenholme. ***Foxboro.***—F. J. Wood. ***Gloucester.***—H. W. Spooner. ***Haverhill.***—R. R. Evans. ***Holyoke.***—E. P. Butts, E. A. Ellsworth, J. L. Tighe. ***Hyde Park.***—E. A. W. Hammatt. ***Lawrence.***—R. A. Hale, I. L. Sjöström. ***Lee.***—W. W. Maclay. ***Lowell.***—G. Bowers, C. L. Hammond, G. A. Nelson, A. T. Safford. ***Lynn.***—C. W. Gay. ***Malden.***—H. A. Carson, R. L. Read. ***Melrose.***—C. T. Fernald. ***Middleboro.***—W. R. Farrington. ***New Bedford.***—A. B. Drake, W. F. Williams. ***New Lenox.***—J. L. Howard. ***Newton Center.***—D. H. Andrews. ***Newton Highlands.***—S. E. Thompson. ***North Adams.***—W. I. Baucus, F. B. Locke. ***North Attleborough.***—F. T. Westcott. ***Roxbury.***—H. N. Cheney. ***Sandwich.***—H. W. Durham, F. D. Fisher. ***Sharon.***—E. S. Safford. ***Shelburne Falls.***—J. H. Brace. ***Somerville.***—W. F. Goodrich. ***South Framingham.***—E. H. Howard. ***South Yarmouth.***—C. H. Davis. ***Springfield.***—S. M. Green, E. E. Lochridge, G. N. Merrill, C. M. Slocum, E. E. Stone, D. M. Wheeler. ***Taunton.***—L. Dean. ***Tufts College.***—F. B. Sanborn. ***Turners Falls.***—C. W. Hazelton. ***Wakefield.***—G. M. Tompson. ***Walpole.***—W. L. Bowker. ***Waltham.***—B. Brewer, C. R. Perry. ***Wellesley.***—T. W. Baldwin. ***Westborough.***—W. J. Mozart. ***Westfield.***—O. E. Parks. ***West Medford.***—T. H. Barnes. ***West Newton.***—W. P. Morse, E. H. Rogers, H. D. Woods. ***West Roxbury.***—H. Manley. ***Worcester.***—C. A. Allen, C. M. Allen, R. H. Brown, W. E. Buck, T. H. Coe, V. P. Curtis, A. W. French, L. B. Jenckes, J. A. Johnston, E. F. Miner, O. W. Norcross, H. Parker, S. H. Pitcher.

ASSOCIATE MEMBERS.—***Beverly.***—C. H. Farnham. ***Boston.***—C. S. Allen, J. V. Beekman, Jr., E. P. Bliss, B. S. Brown, G. P. Carver, P. M. Churchill, H. E. Cowan, L. S. Cowles, J. E. Cunningham, G. W. Cutting, Jr., F. W. Daggett, C. H. Dutton, G. D. Emerson, A. D. Fuller, S. E. Ganser, R. D. Gardner, R. K. Hale, E. P. Hendrick, H. K. Higgins, J. H. Hood, T. E. Lally, E. P. Lane, W. H. Law, J. H. Manning, H. S. Morse, C. E. Parsons, W. T. Reed, J. H. Richardson, E. F. Rockwood, N. H. Sanderson, A. L. Scott, W. H. Sears, E. R. Simpson, T. W. Souther, W. F. Steffens, D. Y. Swaty, F. L. Tibbetts, H. F. Tucker, R. M. Whittet. ***Buzzards Bay.***—C. T. Waring. ***Cambridge.***—E. F. Atwood, F. H. Carter, C. W. Killam, H. F. Sawtelle. ***Charlestown.***—C. Goldsmith, E. C. Hayden. ***Clinton.***—E. R. B. Allardice. ***East Pepperell.***—F. C. Woodward. ***Fall River.***—W. E. Noble. ***Fitchburg.*** F. C. Davis. ***Gleasondale.***—W. C. Lambert. ***Holyoke.***—A. F. Sickman. ***Housatonic.***—J. M. Race. ***Lowell.***—H. J. Wild. ***Ludlow.***—C. E. Quinby. ***Malden.***—W. E. Barnes. ***Manchester.***—R. C. Allen. ***New Bedford.***—I. M. Chace, Jr., R. D. Chase, W. H. Chase. ***Newton Highlands.***—W. O. Lichtner. ***Newtonville.***—L. E. Moore. ***Pittsfield.***—G. R. Brown, A. B. Farnham, C. B. Lindholm, F. A. Spaulding, M. M. Thrane. ***Quincy.***—J. K. Freitag, P. Lawton. ***Sandwich.***—A. S. Ackerman. ***Shelburne Falls.***—A. A. Conger, J. C. Hilton. ***South Framingham.***—W. W. Locke. ***South Hadley Falls.***—M. J. Leahy. ***Springfield.*** A. R. Klein, W. B. Thomson. ***Tufts College.***—E. H. Rockwell. ***Waltham.***—H. B. Pratt. ***Westfield.***—J. L. Hyde. ***West Roxbury.***—C. R. Gow. ***Winchester.***—D. M. Belcher. ***Winthrop.***—G. M. Stevens. ***Worcester.***—H. C. Ives, R. L. Whipple, H. P. Wilson.

ASSOCIATES.—***Boston.***—C. H. Eglee, H. W. Hayward, H. A. Phillips, C. P. Price. ***Pittsfield.***—E. T. Belden. ***West Chelmsford.***—J. J. Monahan. ***West Newton.***—C. W. Ross.

JUNIORS.—***Boston.***—E. W. Bowditch, F. A. Marston, W. Tufts. ***Buzzards Bay.***—L. Gurney. ***Cambridge.***—J. J. Chamberlain, Jr., J. R. Nichols. ***Dorchester.*** G. C. Stone ***East Braintree.***—H. C. Poore. ***Fort Banks.***—W. E. Day. ***Jamaica Plain.***—G. Johnson. ***Medford Hillside.***—E. A. Norwood. ***New Bedford.***—E. J. Potter. ***Pittsfield.***—J. M. Barker. ***Roslindale.***—W. B. Bushway. ***Roxbury.***—H. Nawn. ***Shelburne Falls.***—E. P. Hamilton, J. A. Silsbee. ***Springfield.***—A. C. King. ***Tufts College.***—H. G. Payrow. ***Waltham.***—W. W. Bigelow, G. Small. ***Worcester.***—T. L. Paul.

FELLOWS.—***Swampscott.***—S. Holman.

MICHIGAN. Total Membership, 99.

MEMBERS.—***Ann Arbor.***—M. E. Cooley, C. T. Johnston, C. L. de Muralt, E. D. Rich, G. S. Williams. ***Detroit.***—A. B. Atwater, F. T. Barcroft, A. Dow, H. H. Esselstyn, G. H. Fenkell, J. D. Hawks, H. S. Hodge, F. B. Howard, J. C. Hutchins, G. H. Kimball, M. S. MacDiarmid,

R. H. McCormick, T. F. McCrickett, D. A. Molitor, F. G. Ray, C. McD. Townsend, J. A. Ubsdell, Jr., H. A. E. C. von Schon, G. H. Webb, A. J. Wenzell, E. S. Wheeler, S. D. Williams, Jr. ***Dexter.***—J. B. Davis. ***Flint.***—H. E. Terry. ***Grand Rapids.*** E. H. Barnes, L. W. Goddard, E. N. Layfield, D. McCool, K. S. Riser. ***Jackson.*** W. G. Fargo, R. M. Newman. ***Kalamazoo.***—G. S. Pierson. ***Lapeer.***—F. Morley. ***Manistee.***—E. W. Muenscher. ***Marquette.***—R. C. Young. ***Sault Ste. Marie.***—L. H. Davis, I. De Young, W. J. Graves, L. C. Sabin.

ASSOCIATE MEMBERS.—***Ann Arbor.***—C. A. Ellis, A. E. Greene, H. B. Merrick, C. J. Tilden. ***Bay City.***—R. E. Andrews, R. M. Coomer. ***Detroit.***—G. R. Cooke, J. E. Evans, W. J. Fairbairn, N. C. Fenkell, G. S. Gildersleeve, M. Goldenberg, J. T N. Hoyt, G. D. Huntington, O. W. Irwin, J. Kahn, P. M. Louwerse, E. H. Owen, C. A. Park, J. H. Poole, W. S. Richmond, R. D. Snodgrass, R. R. Tinkham, R. B. Titsworth, E. M. Walker. ***Grand Rapids.***—G. M. Ames, W. S. Bake, J. R. Fitzpatrick, R. E. Harrison. ***Houghton.***—G. H. Banks, R. R. Wiggins. ***Port Huron.***—R. LeH. Mahon.

ASSOCIATES.—***Ann Arbor.***—H. H. Atwell. ***Grand Rapids.***—F. L. Gaines. ***Saginaw.***—G. L. Burrows.

JUNIORS.—***Ann Arbor.***—L. E. Ayres, A. J. Decker, H. K. Holland, F. N. Menefee, C. W. Spooner. ***Detroit.***—J. Cochran, L. A. Estes, L. F. Murphy, R. A. Reynolds. ***Flint.***—C. I. Auten. ***Grand Rapids.***—W. W. Tefft. ***Ionia.*** C. R. Marsh. ***Ishpeming.***—C. B. Hawley. ***Jackson.***—C. A. Biggs, G. H. Knutson. ***Kalamazoo.***—C. F. Peck. ***Sault Ste. Marie.***—W. M. Rich, R. R. Ryan, S. D. Strong. ***Wells.***—G. T. Stephenson.

MINNESOTA. Total Membership, 65.

MEMBERS.—***Albany.***—S. Wimmer. ***Duluth.***—H. C. Ash, C. Coleman, J. H. Darling, F. E. House, W. H. Hoyt, T. F. McGilvray, W. B. Patton, D. A. Reed, G. A. Taylor. ***Elk River.***—D. C. Washburn. ***Mankato.***—W. F. Brooks. ***Minneapolis.***—F. H. Bass, W. Buehler, F. W. Cappelen, F. H. Constant, W. P. Cowles, W. de la Barre, L. S. Gillette, J. B. Gilman, W. S. Hewett, E. H. Loe, W. D. Lovell, C. H. Prior, F. C. Shenehon, H. E. Stevens, C. A. P. Turner, G. L. Wilson. ***Northfield.***—G. W. Sublette. ***St. Paul.***—C. Le R. Annan, R. B. C. Bement, O. Claussen, W. L. Darling, J. R. W. Davis, A. H. Hogeland, G. H. Hutchinson, C. J. A. Morris, D. C. Shepard, H. E. Stevens, L. P. Wolff.

ASSOCIATE MEMBERS.—***Deerwood.***—W. F. Collar. ***Duluth.***—F. A. Cokefair, S. G. Collins, W. G Zimmermann. ***Minneapolis.***—J. G. Anderson, E. H. Bruntlett, A. S. Cutler, R. Hamlin, F. M. Henry, S. G. Jones, W. N. Jones, O. B. Nelson, L. S. Oakes, B. W. Ranson, R. D. Thomas. ***St. Paul.***—K. Alexander, A. F. Meyer, J. C. Sesser, P. E. Stevens, J. T. Stewart, M. J. Thompson, M. Toltz.

ASSOCIATES.—***St. Paul.***—H. Elliott.

JUNIORS.—***Minneapolis.***—D. I. Okes.

FELLOWS.—***St. Paul.***—J. J. Hill.

MISSISSIPPI. Total Membership, 27.

MEMBERS.—***Clarksdale.***—A. L. Dabney, T. G. Dabney. ***Gautier.***—J. B. Lindsey, Jr. ***Greenville.***—A. Hider, R. Somerville, C. H. West. ***Greenwood.***—E. A. Steece. ***Jackson.***—W. G. Kirkpatrick, M. L. Lynch. ***Natchez.***—E. B. Geddes. ***Vicksburg.***—H. M. Marshall, A. M. Todd, E. C. Tollinger.

ASSOCIATE MEMBERS.—***Greenville.***—W. E. Elam. ***Hattiesburg.***—J. W. Davenport. ***Jackson.***—F. P. Hamilton. ***Pass Christian.***—S. L. McGlathery. ***Vicksburg.***—A. W. Dann, E. S. Maupin, A. A. Woods.

JUNIORS.—***Agricultural College.***—R. W. Gay. ***Jackson.***—M. L. Culley, C. H. Shapleigh. ***Vicksburg.***—P. E. Cunningham, G. P. F. Jouine, R. C. Lilly, R. L. Tatum.

MISSOURI. Total Membership, 197.

MEMBERS.—***Columbia.***—C. Hill, A. L. Hyde, F. P Spalding. ***Independence.***—E. M. Stayton. ***Joplin.***—J. C. Barr. ***Kansas City.***—C. A. Alderman, L. R. Ash, R. C. Barnett, E. J. Beard, A. M. Blodgett, D. Bontecou, C. S. Burns, V. H. Cochrane, W. W. Colpitts, J. L. Darnell, H. E. Eckles, G. E. Ellis, H. A. Fitch, S. W. Fox, J. V. Hanna, E. A. Harper, J. L. Harrington, I. G. Hedrick, H. O. Hem, F. W. Honens, J. W. Hoover, W. Kiersted, W. S. Kinnear, J. A. Lahmer, R. J. McCarty, R. E. McDonnell, A. Maitland, Jr., H. K. Seltzer, H. F. Taylor, L. Treadwell, A. A. Trocon, J. Tuthill, J. A. L. Waddell, R. W. Waddell, R. P. Woods. ***Marceline.***—G. J. Bell. ***Rolla.***—E. G. Harris. ***St. Louis.***—W. G. Brenneke, B. L. Brown, O. W. Childs, B. H. Colby, A. O. Cunningham, E. B. Fay, E. C. Finley, S. B. Fisher, W. L. Fisk, E. Flad, J. T. Garrett, R. P. Garrett, C. Gayler, E. Gray, E. L. Harman, F. T. Hatch, M. L. Holman, J. R. Hudson, F. G. Jonah, C. H. Ledlie, B. McKeen, J. A. McKim, R. E. McMath, C. V. Mersereau, W. S. Mitchell, R. Moore, F. Neher, J. A. Ockerson, F. Y. Parker, E. J. Pearson, H. Phillips, R. H. Phillips, J. Pitzman, C. L. Potter, C. de la C. Purdon, H. L. Reber, H. Rohwer, S. B. Russell, S. K. Smith, C. F. Stephens, H. P. Taussig, J. L. Van Ornum, R. L. Van Sant, E. E. Wall, J. W. Woermann. ***Springfield.***—M. C. Byers, V. K. Hendricks.

ASSOCIATE MEMBERS.—***Benton.***—J. E. Warner. ***Cape Girardeau.***—W. A. O'Brien. ***Columbia.***—E. B. Cauthorn, D. B. Duncan, W. S. Williams. ***Excelsior Springs.***—S. W. Henderson. ***Joplin.***—J. B. Hodgdon. ***Kansas City.***—E. B. Black, J. H. Byrd, F. G. Cudworth, T. Ebashi, L. H. Egan, A. R. Eitzen, A. C. Everham, H. H. Fox, W. S. Haldeman, J. M. Hammond, R. D. M. Henley, J. C. Herring, E. E. Howard, F. D. Hughes, L. A. Hunt, C. E. Johnston, F. A. Jones, J. C. Long, B. Lowther, P. McGeehan, A. M. Meyers, C. N. Miller, C. A. Slayton, C. A. Smith, W. W. K. Sparrow, F. H. Spitzer, G. E. Tebbetts, H. P. Treadway, H. von Unwerth, H. C. Westover, G. N. Wheat, A. H. Worley, J. S. Worley. ***Macon.***—LeR. D. Williams. ***Nevada.***—J. M. Clack. ***Poplar Bluff.***—E. C. Thomes. ***St. Joseph.*** E. Stenger. ***St. Louis.***—A. A. Aegerter, H. R. Andress, P. Aylett, G. G. Black, S. W. Bowen, C. W. Chassaing, F. D. Collins, R. S. Colnon, J. E. Conzelman, H. M. Cryder, A. H. Diamant, E. C. Dicke, C. J. Eld, Jr., V. E. Ellstrom, C. H. Fisk, R. H. P. Ford, W. T. Gray, A. P. Greensfelder, O. F. Harting, W. W. Horner, A. E. Lindau, R. L. Lund, R. McCulloch, L. C. F. Metzger, R. Morey, T. E. Morrison, H. J. Pfeifer, G. A. Pierce, W. H. Prentice, Jr., J. C. Pritchard, J. L. Richmond, H. Rusch, J. W. Skelly, D. D. Smith, W. A. Tyrrell, J. B. Van Vleck, F. L. Wilcox, J. F. Wilhelm, S. L. Wonson. ***Springfield.***—A. C. Polk. ***Webb City.***—A. J. McKenzie.

ASSOCIATES.—***St. Louis.***—E. C. Constance, H. von Schrenk.

JUNIORS.—***Carthage.*** D. N. Wetherell. ***Fruitville.*** L. L. Winans. ***Kansas City.***—O. L. Eltinge, S. Hardesty, A. P. Learned, C. A. Neal, R. A. See, N. T. Veatch, Jr., N. E. Waddell. ***Keytesville.*** -R. C. Gray. ***Kirkwood.***—H. H. Clayton. ***Rolla.***—F. E. Dennie. ***St. Louis.***—J. B. Black, C. C. Brown, L. H. Faidley, C. P. Howes, W. J. Knight, C. F. Phillips, M. Schuyler, H. A. Seltzer, R. L. Williams.

MONTANA. Total Membership, 45.

MEMBERS.—***Armstead.***—T. H. Bacon. ***Butte.***—E. Carroll, E. H. Wilson. ***East Helena.***—W. A. Allen. ***Great Falls.***—S. B. Robbins, F. Scotten. ***Helena.***—M. H. Gerry, Jr., R. O. Hayt, H. N. Savage. ***Intake.***—J. Wright. ***Malta.***—G. O. Sanford. ***Missoula.***—F. Beckwith, T. M. Ward. ***St. Ignatius.***—E. F. Tabor. ***Valier.***—W. E. Swift.

ASSOCIATE MEMBERS. ***Augusta.***—C. B. Long. ***Butte.***—C. A. W. Musson. ***Fort Shaw.***—C. L. Bailey, H. O. Beale, J. B. Bond, A. J. Hayes. ***Glendive.***—C. W. Bowles, L. H. Mitchell. ***Helena.***—R. M. Conner, G. L. Davis, A. J. Fisk, Jr., C. E. Hayes, W. A. Lamb, E. A. Moritz, R. M. Snell, G. E. Stratton. ***Huntley.***—C. D. Howe. ***Laurel.***—C. E. Shipman. ***Missoula.***—D. C. Trott. ***Ronan.***—C. J. Moody. ***St. Ignatius.***—W. N. Hill. ***Valier.***—H. J. Saunders.

JUNIORS.—***Bonner.***—W. W. Mitchell. ***Glendive.***—R. T. Hurdle. ***Helena.***— B. E. Jones. ***Miles City.***—G. C. Pruett. ***Missoula.***—J. C. Beebe. ***Ronan.***—L. D. Graham. ***St. Ignatius.***—F. Towle. ***Valier.***—C. E. Atwood.

NEBRASKA. Total Membership, 26.

MEMBERS.—***Lincoln.***—F. T. Darrow, A. Dobson, W. Grant. ***Omaha.***—G. L. Campen, E. Holbrook. ***South Omaha.***—W. S. King.

ASSOCIATE MEMBERS.—***Falls City.***—J. A. Crook, A. M. Munn. ***Mitchell.***—A. Weiss. ***Neligh.***—N. B. Sweitzer. ***Omaha.***—A. C. Arend, H. Bortin, J. A. Bruce, G. J. S. Collins, G. W. Craig, A. M. Crain, H. A. Holdrege, A. C. Koenig, E. E. Larkins, R. A. Swartwout. ***Scottsbluff.***—O. T. Reedy. ***York.***—W. J. Ryan.

JUNIORS.—***Alliance.***—F. C. Huntsman. ***Lincoln.***—D. D. Price. ***Omaha.***—T. J. Schmidt, R. B. Wright.

NEVADA. Total Membership, 8.

MEMBERS.—***Fallon.***—D. W. Cole. ***McGill.***—L. Duncan. ***Reno.***—A. S. Kibbe.

ASSOCIATE MEMBERS.—***Hawthorne.***—L. B. Spencer. ***Lahonton.***—J. E. Bell, F. H. Tillin hast. ***Reno.***—E. B. Bumsted, D. W. Hays.

NEW HAMPSHIRE. Total Membership, 11.

MEMBERS.—***Derry Village.***—J. C. Chase. ***Greenville.***—S. C. Heald. ***Hanover.***—W. W. Cummings, R. Fletcher, J. V. Hazen. ***Hill.***—G. Hodges. ***Portsmouth.***—L. E. Gregory.

ASSOCIATE MEMBERS.—***Berlin.***—C. F. Lovett. ***Hanover.***—C. A. Holden. ***North Woodstock.***—C. R. Adams. ***Portsmouth.***—H. LeG. Hilton.

NEW JERSEY. Total Membership, 196.

MEMBERS.—***Allenhurst.***—E. B. Gumaer. ***Andover.***—G. Leighton, H. E. Wagner. ***Atlantic City.***—J. W. Hackney. ***Atlantic Highlands.***—W. S. Auchincloss. ***Bayonne.***—T. H. Alison, F. H. Baldwin, G. F. Morse, A. Smith. ***Bogota.***—St. J. Clarke. ***Bridgeton.***—O. Smith. ***Camden.***—H. C. Felton, H. M. Herbert, DeC. May, E. H. Sapp. ***East Orange.***—A. Carr, J. P. Churchill, W. H. V. Reimer, P. A. Seurot, G. W. Swinburne. ***East Rutherford.***—W. F. Kauffmann. ***Elizabeth.***—J. L. Bauer, W. H. Luster, Jr. ***Flanders.***—C. G. Force. ***Hoboken.***—T. H. McCann, G. J. Ray, F. S. Tainter, W. F. Whittemore. ***Jersey City.***—M. L. Gardner, E. W. Harrison, C. H.

Higgins, R. S. Parsons, C. A. Van Keuren. ***Montclair.***—G. B. Cornell, F. D. Leffingwell. ***Morristown.***—A. B. Lueder. ***Newark.***—H. A. Benedict, R. E. Danforth, W. P. Field, J. C. Hallock, W. N. Hazen, H. A. Hickok, W. A. Howell, G. Lehlbach, J. Owen, J. H. Philips, E. S. Rankin, A. M. Reynolds, J. M. Schreiber, M. R. Sherrerd, M. N. Shoemaker, W. G. Taylor. ***Passaic.***—J. H. Edwards, A. B. Proal, Jr., C. R. Wise. ***Paterson.***—W. W. Christie, J. H. Cook, A. W. Cuddeback, J. W. Ferguson, E. LeB. Gardner, J. A. Nelson, A. E. Schneeweiss. ***Pequannock.***—O. Benson. ***Phillipsburg.*** P. H. De Witt. ***Plainfield.***—R. C. Brown, C. E. L. B. Davis, R. H. Hood, C. G. E. Larsson, W. F. Merrill, M. A. Zook. ***Princeton.***—C. McMillan. ***Red Bank.***—G. McC. Taylor. ***Ridgewood.***—J. L. Dodge. ***Roselle.***—G. P. Janes. ***South Orange.***—A. Coffin, J. B. Duncklee. ***Summit.***—C. P. Bassett. ***Tenafly.***—W. G. Clark, H. O. Pond. ***Trenton.***—W. B. Bamford, C. E. Hewitt, C. A. Mead.

ASSOCIATE MEMBERS.—***Arlington.***—J. F. Scrimshaw. ***Atlantic City.***—J. H. Decker, H. W. Hudson, A. H. Nelson, E. D. Rightmire. ***Bayonne.***—J. L. Gray. ***Camden.***—C. F. Class. ***Cranford.***—J. C. Park. ***East Orange.***—J. H. Quimby, A. A. Reimer, F. A. Reimer, C. H. Splitstone, A. W. Stephens. ***Elizabeth.***—T. C. Fischer. ***Fanwood.***—R. L. G. Meggy. ***Flemington.***—P. I. Craig. ***Hackensack.***—S. J. Ott, E. W. Stevens. ***Hoboken.***—J. W. Obreiter. ***Jersey City.***—J. Alsberg, C. W. Bance, A. S. Hamill, G. W. Kinne, J. P. McLean, W. V. McMenemen, A. L. Moorshead, T. J. Wasser, N. D. Wortendyke. ***Johnsonburg.***—O. C. Edwards, Jr. ***Little Falls.***—H. E. Van Ness. ***Maurer.***—M. S. Darrow, C. N. Forrest, R. L. Fowler. ***Metuchen.***—J. G. Tait. ***Montclair.***—C. A. D. Bayley, G. Immediato, S. Johannesson, A. E. Owen. ***Morristown.***—W. F. R. Griffith. ***New Brunswick.***—S. A. Stephenson, Jr. ***Newark.***—H. E. Bushnell, J. S. Crane, E. R Halsey, H. G. Harrington, J. W. Heller, W. A. Kinsey, H. P. Kreiner, W. S. Logan, L. A. Robb, F. Rosenberg, K. G. Smith, J. E. Snell. ***Newton.***—F. E. Caldwell. ***Paterson.***—H. J. Hewat, J. E. Torrey. ***Perth Amboy.***—E. A. Lee, S. J. Mason, F. L. Smith. ***Phillipsburg.***—W. R. Dunn, R. P. Howell. ***Plainfield.***—De W. D. Barlow, C. Gilman. ***Princeton.***—H. A. Harris, J. Stockton. ***Rahway.***—J. J. Vail. ***Red Bank.***—T. H. Grant. ***Trenton.***—P. L. Braunworth, N. A. K. Bugbee, T. E. Collins, L. Focht, A. C. Gregory, A. Hirst, A. G. Nicolaysen, S. A. Roake. ***Upper Montclair.***—W. Burton. ***Ventnor City.***—L. G. Krause. ***Weehawken.***—G. W. Bond, Jr. ***Woodbury.***—J. D. Jaques.

ASSOCIATES.—***Burlington.***—W. R. Conard. ***East Orange.***—J. A. Dailey. ***Hoboken.***—C. O. Gunther. ***Jersey City.***—J. J. Ferris. ***Plainfield.***—G. H. Frost, E. L. Ransome. ***Princeton.***—H. S. S. Smith, F. N. Willson. ***Ridgewood.***—G. La P. Denio.

JUNIORS.—***Bayonne.***—S. J. Harwi, H. H. Sims. ***Cliffside Park.***—S. W. McClave, Jr. ***East Orange.***—W. C. van Duyne. ***Elizabeth.***—L. Powers. ***Hackensack.***—W. G. Broadhurst. ***Jersey City.***—W. H. Baines, W. Heyman, I. Rossi. ***Montclair.***—K. D. Owen. ***Newark.***—F. H. Earle, J. E. Payne. ***Newton.***—A. W. Muir. ***Passaic.***—R. S. Wise. ***Paterson.***—H. S. Speidel. ***Perth Amboy.***—J. G. Hendrie, S. E. Page. ***Princeton.***—R. L. Cary. ***Red Bank.***—A. C. Swift. ***Ridgewood.***—R. V. Banta. ***Trenton.***—J. N. Brooks, G. E. Herchkovitz, H. P. Letton, F. S. MacIlvaine. ***Upper Montclair.***—C. P. Snook. ***Westfield.***—H. A. Brainerd.

FELLOWS.—***Landing.***—J. Watson.

NEW MEXICO. Total Membership, 17.

MEMBERS.—***Albuquerque.***—H. F. Labelle. ***Elephant Butte.***—J. D. Fauntleroy, H. J. Gault. ***Raton.***—O. H. B. Turner.

ASSOCIATE MEMBERS.—***Agricultural College.***—F. L. Bixby. ***Albuquerque.***—H. F. Robinson. ***Black Rock.***—R. Ritter. ***East Las Vegas.***—G. E. Morrison. ***Elephant Butte.***—La V. J. Charles, W. H. W. Yeo. ***Fort Bayard.***—C. T. Leeds. ***Liberty.***—E. C. Gersbach. ***Roswell.***—J. W. Stewart. ***Tucumcori.***—H. E. Stansbury. ***Turley.***—O. J. Turley.

JUNIORS.—***Elephant Butte.***—H. S. Stanton. ***Selden.***—E. Patterson.

NEW YORK. Total Membership, 1698.

MEMBERS.—***Albany.***—H. Andrews, M. G. Barnes, J. A. Bensel, E. A. Bond, G. H. Burgess, E. Hayes, W. R. Hill, L. Holmes, R. E. Horton, T. Horton, A. E. Kastl, P. McLoud, W. R. Marden, C. T. Middlebrook, H. C. Parsons, A. H. Perkins, J. Ripley, D. C. Serber, R. W. Sherman, C. S. Sims, G. F. Stickney, C. F. Stowell, A. H. Sutermeister, E. A. Touceda, E. F. Van Hoesen, F. C. Woermann. ***Albion.***—S. Hazard. ***Amsterdam.***—F. E. Crane, J. B. Wright. ***Andes.***—J. A. Kelley. ***Angelica.***—H. S. Wilgus. ***Auburn.***—J. W. Ackerman. ***Baldwinsville.***—C. W. Sturtevant. ***Ballston.***—H. M. Geer. ***Brewerton.***—F. C. Shepherd. ***Broadalbin.***—W. P. Judson. ***Brooklyn.***—H. R. Asserson, V. B. Bergen, A. S. F. Berquist, G. Berry, S. P. Brown, P. P. Farley, G. R. Ferguson, C. L. Fitch, W. G. Ford, E. J. Fort, W. H. Gahagan, M. Gay, W. T. Gould, W. G. Gove, J. H. Granbery, C. R. Grimm, E. G. Haines, G. T. Hammond, F. R. Harris, S. U. Hopkins, G. Kaufman, F. McD. Leavitt, A. McLean, J. C. Meem, W. S. Menden, L. V. Morris, F. C. Noble, H. L. Oestreich, H. L. Potter, F. E. Pratt, S. M. Purdy, C. B. Rowland, T. F. Rowland, Jr., R. L. Russell, G. S. Skilton, C. W. Smith, H. C. Stowe, J. Strachan, E. C. Swezey, W. R. Tenney, G. A. Tibbals, S. G. Tibbals, G. W. Tillson, C. G. Williams, C. J. Wolfe. ***Brown Station.***—C. E. Davis, M. J. Look. ***Buffalo.***—F. M. Ashmead, F. V. E. Bardol, G. B. Bassett, C. S. Boardman, C. C. Conkling, L. LeR. Davis, D. A. Decrow, G. C. Diehl, G. S. Field, S. J. Fields, E. B. Guthrie, E. E. Haslam, W. A. Haven, E. Hayes, A. L. Johnson, S. T. M. B. Kielland, L. H. Knapp, E. Low, E. P. Lupfer, H. L. Lyon, C. J. McDonough, C. G. Moore, J. C. Quintus, L. H. Rathman, G. A. Ricker, G. T. Roberts, H. H. Shepard, T. G. Smith, F. J. Tresise, W. E. Wilson, J. F. Witmer. ***Catskill.***—J. W. Kittrell, C. H. Van Orden. ***Chatham.***—W. P. Boright. ***Cold Spring.***—J. G. Peck. ***Cooperstown.***—J. K. Choate. ***Dansville.***—E. T. Scovill.

Dongan Hills.—F. W. Abbot. ***Elmira.***—E. E. Buchanan. ***Elmira Heights.***—H. W. Preston. ***Fairport.***—H. B. Brewster, T. J. Morrison. ***Far Rockaway.***—C. R. Bettes. ***Fishkill.***—J. D. Fouquet. ***Forest Hills.***—I. Harby. ***Fort Edward.***—E. V. R. Payne. ***Fulton.***—O. C. Breed, W. H. Cushman, T. M. Ripley. ***Geneva.***—C. T. Church. ***Great Neck Station.***—C. Worthington. ***Groton.***—E. A. Landon. ***Hastings-on-Hudson.***—G. A. Noska. ***Islip.***—E. R. Smith. ***Ithaca.***—R. C. Carpenter, C. L. Crandall, E. E. Haskell, O. M. Leland, H. N. Ogden. ***Jamaica.***—F. Auryansen, J. M. Belknap, T. J. Carlile, O. Erlandsen, R. Evans, J. R. Savage, E. H. Thomes. ***Jamestown.***—E. C. Burns. ***Kingston.***—F. K. Betts, E. B. Codwise, L. B. Vaughan. ***Linoleumville.***—D. N. Melvin. ***Lockport.***—F. W. McElroy. ***Long Island City.***—W. C. Briggs, H. K. Endemann, G. A. Just, W. D. Kelley, L. C. L. Smith. ***Lyons Falls.***—H. Constable. ***Massena.***—I. G. Calderwood, J. W. Rickey. ***Mechanicsville.***—R. P. Bloss, F. P. Williams. ***Middletown.***—E. Canfield, D. R. Lee, A. G. Norton. ***Millwood.***—C. M. Bolton. ***Mohegan Lake.***—C. H. Baker. ***Montezuma.***—J. G. Palmer. ***Mt. Vernon.***—C. A. Hammond, C. H. Quimby, Jr. ***New Brighton.***—T. S. Oxholm, J. D. Van Buren. ***Newburgh.***—E. Garrison, N. H. Janvrin. ***New Dorp.***—A. N. Spooner. ***New Hartford.***—A. M. Scripture. ***New Paltz.***—W. R. Neely. ***New Rochelle.***—H. Crosby, H. A. Van Alstyne, J. K. Wilkes. ***New York City*.***—E. L. Abbott, W. I. Aims, H. C. Alden, C. H. Allen, K. Allen, R. F. Almirall, J. W. Armstrong, W. H. Arnold, H. E. Arthur, P. H. Ashmead, T. C. Atwood, G. Aus, W. E. Austin, H. N. Babcock, J. P. Badennausen, C. R. Baffrey, H. C. Baird, W. E. Baker, W. J. Baldwin, G. P. Bard, J. G. Basinger, G. S. Baxter, R. J. Beach, W. E. Belknap, C. C. F. Bent, K. Berle, R. T. Betts, E. J. Beugler, A. W. K. Billings, W. M. Black, F. O. Blackwell, A. H. Blanchard, F. Blossom, J. Bogart, V. G. Bogue, A. P. Boller, R. P. Bolton, G. W. Booth, A. L. Bowman, J. C. Boyd, J. C. Brackenridge, F. E. Bradley, O. Brainard, G. W. Bramwell, J. Breuchaud, J. A. Briggs, A. G. Brinckerhoff, C. O. Brown, L. L. Brown, P. G. Brown, T. E. Brown, J. L. Brownlee, C. W. Bryan, C. W. Buchholz, R. S. Buck, A. W. Buel, E. D. Buel, G. B. Burbank, F. A. Burdett, A. S. Burgess, W. H. Burr, H. G. Burrowes, L. Bush, Le R. H. Byam, M. L. Byers, J. P. Carlin, A. W. Carpenter, A. E. Carter, H. J. Chambers, R. H. Chambers, T. F. Chappell, J. E. Childs, G. L. Christian, G. L. Christy, F. B. Church, G. H. Clark, T. S. Clark, G. C. Clarke, J. B. Clermont, H. J. Cole, D. C. N. Collins, R. G. Collins, Jr., C. K. Conard, S. P. Connor, C. E. Conover, F. S. Cook, R. D. Coombs, S. E. Coombs, T. Cooper, J. N. H. Cornell, E. L. Corthell, W. H. Coverdale, A. S. Crane, C. A. Crane, A. Craven, W. W. Crehore, B. F. Cresson, Jr., R. W. Creuzbaur, J. L. Crider, F. Crowell, S. Dahm, A. 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Hayes. ***Stone Ridge.***—M. H. Freeman. ***Syracuse.***—R. L. Allen, L. D. Brownell, H. N. Cole, A. G. Crysler, W. S. Manning, Jr., G. L. Noble, D. B. O'Brien, M. B. Palmer, A. W. Rogers, E. P. Roundey, F. W. Sarr, C. H. Thompson, H. G. Throop, S. B. Vernon, D. C. Wedgeworth. ***Troy.***—H. W. Benedict, LeR. W. Clark, F. Edwards, W. S. Hamill, W. A. Nial, P. H. Parthesius, W. W. Rousseau. ***Utica.***—H. R. Beebe, C. Kiehm, C. Lewis, Jr., B. C. Martin, H. V. D. Owens, E. Talbot, W. F. Tenney, A. T. Throop, B. E. White. ***Vail Gate.***—J. L. Hildreth, Jr. ***Valhalla.***—C. P. Abbott, G. T. Seabury, W. F. Smith. ***Walden.***—A. Thomson, Jr. ***Waterford.***—E. J. Becker, K. O. Guthrie, H. O. Schermerhorn. ***Waterloo.***—A. E. Steere. ***Watertown.***—J. P. Burns, L. A. Burns, P. H. Winchester. ***Watervliet.***—J. C. Bentley. ***West Point.***—G. B. Pillsbury. ***West Shokan.***—S. K. Clapp, C. A. Garfield, W. D. Hubbard, J. DeW. Justin. ***White Plains.***—F. W. Allen, A. T. Brown, W. F. Jordan, A. H. Pratt, W. B. Reed, Jr., C. R. Wyckoff. ***Wilton.***—F. W. Tooker. ***Yonkers.***—C. E. Carpenter, J. L. Davis, L. Griffith, A. W. Tidd. ***Yorktown Heights.***—H. A. Leeuw.

ASSOCIATES.—***Albany.***—J. R. Watt. ***Binghamton.***—A. L. Gilmore. ***Brooklyn.***—T. Belzner, H. R. Codwise, A. L. Colsten. ***Buffalo.***—L. J. Bennett, J. MacGregor, A. W. Thorn. ***Flushing.***—A. A. Johnson. ***Ithaca.***—I. P. Church, H. S. Jacoby, C. L. Walker. ***New York City.****—E. R. Ackerman, J. W. Auchincloss, R. C. C. M. Bernegau, S. S. Bogart, H. Bouton, L. F. Braine, A. H. Bromley, Jr., J. H. Brown, Jr., J. M. Bruce, M. D. Chapman, G. N. Cole, A. G. Compton, E. J. Connor, W. R. Copeland, W. C. Cuntz, C. G. Currier, C. de Wyrall, E. J. Farrell, W. C. Fisk, A. C. Gildersleeve, J. B. Goldsborough, J. M. Goodell, L. B. Harrison, E. F. Hartmann, J. R. Healy, C. E. Hunt, W. J. Karner, O. B. Keller, W. King, Jr., A. E. Kornfeld, A. Liebman, J. H. Lundberg, H. McBurney, C. F. McKenna, A. L. Marsh, C. Meriwether, H. C. Meyer, Jr., J. Monks, Jr., A. Moyer, W. C. Oastler, R. G. Packard, Jr., E. B. Phelps, L. R. Pomeroy, C. F. Quincy, D. H. Ray, B. Rowntree, C. W. Sass, F. H. Smith, F. V. Smith, J. R. Smith, W. T. Smith, F. Snare, F. M. Talbot, M. Toch, C. Tomkins, F. E. Townsend, J. M. Van Name, M. Watson, J. A. Wells, J. McG. Wood bury, C. G. Young. ***Niagara Falls.***—A. C. Douglass, A. H. G. Hardwicke. ***Poughkeepsie.***—C. M. Christian. ***Tomkins Cove.***—R. I. Odell. ***Troy.***—J. M. Caird, J. M. Diven. ***Watertown.***—C. E. Dewey. ***Yonkers.***—H. J. Kaltenbach, J. M. Lally, T. B. McIntire.

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* Includes the Boroughs of Manhattan and the Bronx.

JUNIORS.—***Albany.***—R. D. Black, A. G. Chapman, H. J. Deutschbein, G. P. Graham, T. P. B. Kennedy, F. H. Macy, J. C. Peck, E. B. Stevenson, G. E. Willcomb. ***Altmar.***—O. McK. Moulton. ***Astoria.***—B. J. Bleistein. ***Atwood.***—M. M. Farley. ***Baldwinsville.***—H. T. Ware. ***Binghamton.*** G. A. Payne. ***Bridge Hampton.***—W. H. Halsey. ***Brooklyn.***—D. A. Allaire, A. E. Barlow, Jr., W. A. Cunningham, W. T. Derleth, A. L. Enger, P. E. Entenmann, H. E. Gill, R. C. Kellogg, F. H. Munkelt, J. Schmitt, J. H. Serra, L. J. Sieling, J. Smith. ***Buffalo.***—H. Chafetz, W. P. Feeley, J. H. Feigel, C. H. Field, H. J. Gardner, Jr., L. H. Hart, J. T. Lillich, F. J. Trelease. ***Canajoharie.***—D. W. Overocker. ***Cohoes.*** J. A. Galvin, F. E. Reed. ***Cold Spring.***—C. M. Gould. ***Cornwall-on-Hudson.***—E. T. King, A. J. Sackett, W. M. Stieve, S. M. Timberlake. ***Croton.***—H. Cantwell. ***East Elmhurst.***—S. W. Moore. ***East Hampton.***—N. N. Tiffany. ***Fairport.***—E. R. Bowerman. ***Flushing.***—A. C. Gregson, F. R. Howe, J. Upton. ***Freeport.***—A. S. Malcomson. ***Hempstead.***—G. M. Estabrook. ***High Falls.***—J. P. Hogan, E. N. Hutchins. ***Ithaca.***—A. P. Mills, L. B. Reynolds. ***Katonah.***—T. DeL. Coffin. ***Kitchawan.***—H. L. Blakeslee. ***Massena.***—R. F. Ward. ***Maybrook.***—B. Strain. ***Mechanicsville.***—F. S. Crowell. ***Medina.***—R. H. Merrill. ***Middleport.***—J. B. T. Colman. ***Middletown.***—C. H. Smith. ***Mt. Vernon.***—F. M. Gaiger. ***New Brighton.***—W. L. Selmer. ***Newburgh.***—H. E. Barnes, C. J. O'Donnell. ***New Paltz.***—D. W. Howes. ***New York City.****—W. J. Barney, F. B. Barshell, L. Bates, Jr., R. C. Becker, G. E. Beggs, S. R. Bellows, O. G. Bennet, Jr., H. M. Bergman, J. E. Beswick, C. S. Bilyeu, C. L. Bogert, R. Booth, C. F. Breitzke, A. E. Budell, O. G. H. Buettner, W. L. Cadwallader, W. T. Chevalier, E. C. Church, J. Clausnitzer, J. X. Cohen, A. W. Coombs, E. K. Cortright, L. G. Cutler, N. B. de Forest, F. H. Densler, E. R. Donle, R. E. Dougherty, T. Eide, H. P. Farrington, W. D. Faucette, J. K. Finch, F. B. Forbes, W. F. Fox, C. W. Gaylord, W. E. Germer, J. H. Glander, Jr., J. W. Du B. Gould, J. F. Greathead, H. M. Hale, H. P. Hamlin, E. F. Hammel, H. S. Harding, F. N. Hatch, C. M. Hathaway, W. W. Havens, H. R. Hayes, A. B. Heiser, W. J. Heiser, A. R. Holbrook, R. T. Holloway, J. J. Hopper, G. W. Howson, Jr., D. C. Johnson, P. Jones, A. C. Kaestner, G. Kingsley, H. C. Kirkwood, F. M. Kuchar, C. A. Latimer, E. P. Leonard, J. Lowry, Jr., L. H. Lubarsky, H. H. E. Lynn, R. W. McMullen, E. J. Mehren, W. Menke, W. R. Morgan, A. R. Murphy, J. F. Murphy, J. C. Nelson, E. Neuhardt, H. Perrine, J. P. H. Perry, C. S. Reed, A. Rheinstein, C. S. Rindsfoos, H. W. Roberts, V. Roberts, W. S. St. John, F. R. Schmid, J. H. Small, Jr., L. I. Smoyer, T. E. Snook, Jr., H. C. Soest, C. B. Spencer, W. H. Starr, G. E. Strehan, N. A. Thayer, J. A. Thompson, D. S. Trowbridge, J. R. Van Horne, H. L. Van Zile, J. L. Vogel, H. C. Walton, E. A. Ward, G. M. Ward, W. H. Warnock, H. B. Wheatcroft, Jr., K. Whitman, Jr., A. J. Willis, S. Wilmot, C. T. Wilson, R. M. Wilson, H. D. Winsor, A. D. Wolff, Jr., W. A. Yeo, A. J. Zabriskie. ***Niagara Falls.***—B. F. Vandervoort. ***Peekskill.***—G. A. Graham. ***Pleasantville Station.***—C. W. Banks. ***Potsdam.***—H. Miller. ***Poughkeepsie.***—P. Beall, H. A. Helling, L. C. Whittemore. ***Purling.***—W. C. Emigh. ***Rhinebeck.***—F. C. Smith. ***Rochester.***—F. L. Bolton, F. S. O'Reilly, W. J. Stewart, C. E. Tirrell. ***Rome.***—F. B. Crocker, W. F. Shaw. ***Schenectady.***—T. S. Bailey, W. L. Drager, L. C. Heilbronner. ***Seneca Falls.***—W. B. Atwood, R. E. Drake. ***Syracuse.***—W. C. Brown, W. C. Walker, J. M. Warner. ***Troy.***—C. D. Calkins, H. McM. Dibert, G. C. See, J. H. Spengler, G. S. Thompson. ***Utica.***—C. E. Merritt. ***Valhalla.***—G. P. Searight, E. L. Sprague, Jr. ***Walden.***—C. Lynde, H. M. Lynde, F. Tingley. ***Wallkill.***—M. Stow. ***Watertown.***—L. B. Cleveland, A. W. Harrington, L. Wachtel. ***Westerleigh.***—G. A. Flynn. ***White Plains.***—H. C. Ellis, E. L. Lincoln, A. L. Sherman. ***Woodhaven.***—T. C. Mott. ***Yonkers.***—J. S. Frazer, N. L. A. Malmros, O. J. Swensson, G. L. Wentworth. ***Yorktown Heights.***—J. C. Gotwals.

FELLOWS.—***Buffalo.***—J. J. Albright, H. A. Richmond. ***New York City.****—E. D. Adams, C. R. Flint, A. W. Kiddle, H. C. Meyer, J. R. Stanton. ***Rochester.***—C. M. Everest.

NORTH CAROLINA. Total Membership, 33.

MEMBERS.—***Asheville.***—C. E. Waddell. ***Burnsville.***—C. L. Ruffin. ***Chapel Hill.***—W. Cain. ***Charlotte.***—J. H. Klinck, W. S. Lee, C. A. Mees. ***Hendersonville.***—W. B. W. Howe. ***Newbern.***—H. T. Paterson. ***Rockingham.***—W. A. Leland. ***Wilmington.***—H. W. Stickle. ***Winston-Salem.***—J. N. Ambler, J. L. Ludlow.

ASSOCIATE MEMBERS.—***Burlington.***—L. R. Whitted. ***Charlotte.***—L. G. Berry, B. S. Drane, J. Firth. ***Durham.***—J. W. Pierce, G. C. White. ***Greensboro.***—J. M. Bandy, E. W. Myers, S. D. Newton. ***Raleigh.***—P. L. Pierce. ***Washington.***—D. B. Packard. ***Wilmington.***—C. L. B. Anderson, D. W. Gross, H. deW. Rapalje. ***Wilson.***—L. Brett. ***Winston-Salem.***—J. L. Dillard.

ASSOCIATES.—***Fayetteville.***—J. F. Wrenn.

JUNIORS.—***Charlotte.***—T. J. Wright, Jr. ***Pee Dee.***—H. V. Joslin. ***West Raleigh.***—R. I. Poole. ***Wilmington.***—F. F. Pillet.

NORTH DAKOTA. Total Membership, 5.

MEMBERS.—***Bismarck.***—T. R. Atkinson. ***Mandan.***—P. E. Thian.

ASSOCIATE MEMBERS.—***Fargo.***—F. La F. Anders. ***University.***—E. F. Chandler. ***Williston.*** R. H. Fifield.

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* Includes the Boroughs of Manhattan and the Bronx.

OHIO. Total Membership, 179.

MEMBERS.—***Akron.***—F. E. Bissell, C. E. Perkins. ***Canton.***—L. E. Chapin, E. J. Landor. ***Chardon.***—J. F. LeBaron. ***Cincinnati.***—F. H. Alfred, W. P. Anderson, W. Archer, W. Baldwin, M. D. Burke, J. W. Hill, H. Jervey, W. C. Jewett, H. M. Knapp, C. S. Millard, J. C. Oakes, B. F. Thomas, H. W. Vehrenkamp, C. A. Wilson. ***Cleveland.***—W. Beahan, W. P. Brown, W. J. Carter, C. H. Clark, F. A. Coleman, J. M. Estep, J. W. Frazier, H. Fuller, B. L. Green, W. O. Henderer, A. J. Himes, R. Hoffmann, A. W. Johnston, M. W. Kingsley, B. R. Leffler, F. W. Lovell, C. H. McKinstry, J. Millis, W. K. Monroe, J. E. A. Moore, A. Mordecai, B. F. Morse, F. C. Osborn, J. T. Pardee, R. W. Pratt, W. P. Rice, F. D. Richards, J. Ritchie, S. Rockwell, R. E. Sheal, J. C. Spencer, E. M. Sprague, C. Staley, G. H. Tinker, G. R. Wadsworth, W. J. Watson, F. C. Williams, C. H. Wright, A. W. Zesiger. ***Columbus.***—F. W. Blackford, E. G. Bradbury, P. Burgess, F. L. Chase, F. H. Eno, J. Griggs, C. T. Morris, E. G. Robinson, E. D. Wickes. ***Dayton.***—H. E. Talbott. ***East Cleveland.***—F. W. Lepper. ***East Liverpool.***—W. R. W. Griffin. ***Elyria.***—W. H. Searles. ***Martins Ferry.***—J. Blodgett. ***Massillon.***—E. Rice. ***Mt. Vernon.***—I. M. Wolverton. ***Sandusky.***—C. A. Judson. ***Springfield.***—G. Thompson. ***Swanton.***—W. T. Blunt. ***Toledo.***—C. S. Davis, J. E. Ferguson, C. L. Gates, G. A. Gessner, Jr., P. J. Reich, G. V. Rhines, H. E. Riggs, M. J. Riggs, W. J. Sherman. ***Washington Court House.***—R. C. Hunt. ***Wauseon.***—G. E. Howe. ***Zanesville.***—J. K. Geddes.

ASSOCIATE MEMBERS.—***Akron.***—J. A. Donahey, J. C. Lathrop, L. P. Winterhalter. ***Bayridge.***—S. B. Newberry. ***Bellefontaine.***—T. W. Hill. ***Canton.***—M. C. Bland. ***Cincinnati.***—F. E. Ayer, J. E. Barlow, G. H. Gilbert, J. A. Hiller, H. C. Innes, E. O. Keator, C. A. Paquette, H. Schneider, C. S. Sheldon, C. M. Stegner, J. Stewart. ***Circleville.***—O. W. Stiles. ***Cleveland.***—H. E. Baldwin, E. W. Cunningham, A. M. Currier, P. P. Evans, J. E. Grady, A. Gravelle, C. W. Lundoff, L. H. Miller, F. H. Neff, C. J. Paterson, F. A. Pease, J. H. Roach, C. W. Schubert, A. L. Stevens, E. B. Thomas. ***Cleveland Heights.***—R. H. Lee. ***Columbus.***—L. C. F. Balz, H. D. Bruning, R. S. Jones, J. W. Mair, N. D. Monsarrat. ***Dayton.***—R. T. Robinson. ***Delaware.***—E. J. Nelson. ***East Akron.***—C. B. Patterson. ***Elyria.***—E. J. Crisp. ***Fairport Harbor.*** -G. S. Meek. ***Garrettsville.***—W. V. Alford. ***Jefferson.*** J. S. Matson. ***Lakewood.***—J. R. Poe. ***Little Hocking.*** - C. J Rannells. ***Madisonville.***—T. Green. ***Mansfield.***—L. A. Keith. ***Massillon.***—W. I. Tompkins. ***Mt. Vernon.***—C. G. Conley. ***Norwood.***—N. O. Goldsmith. ***Sandusky.***—C. M. King. ***Sharonville.***—A. M. Turner. ***Toledo.***—L. M. Gram, C. O. Lasley, G. Scott, A. H. Smith. ***Troy.***—M. Cilley. ***Youngstown.***—J. Hunter. ***Zanesville.***—H. E. Frye, D. Y. Geddes.

ASSOCIATES.—***Cincinnati.***—R. Anderson. ***Cleveland.***—E. M. Graves, H. W. King, W. P. Palmer, C. B. Stowe. ***Columbus.***—D. W. Brooks. ***Dayton.***—D. H. Morris.

JUNIORS.—***Akron.***—R. W. Ferris. ***Bowling Green.***—R. M. Strohl. ***Cincinnati.***—E. J. B. de Mey, E. K. Ruth, O. E. Selby, G. Warner. ***Cleveland.***—J. W. Carpenter, S. T. Henry, H. W. Maynard, K. H. Osborn. ***Columbus.***—W. H. Dittoe. ***Martins Ferry.***—A. H. Doering. ***Massillon.***—H. McC. Yost. ***Steubenville.***—A. P. Holloway. ***Toledo.***—W. G. Clark, H. C. McClure, E. L. Thomssen, H. S. Thorne. ***Troy.***—H. Y. Gard. ***Washingtonville.***—C. D. Bossert.

OKLAHOMA. Total Membership, 24.

MEMBERS.—***Mill Creek.***—J G. Bloom. ***Oklahoma.***—H. V. Hinckley. ***Purcell.***—F. C. Hand. ***Shawnee.***—F. D. Brown.

ASSOCIATE MEMBERS.—***Bartlesville.***—A. J. McNeil. ***Chandler.***—P. M. Speicher. ***Clinton.***—J. L. O'Hearn. ***Miami.***—E. H. Doyle. ***Muskogee.***—J. P. Gallager, E. M. Graham, P. A. Hartung, C. Schultz. ***Oklahoma.***—W. L. Benham, G. V. McClure, C. M. Pritchard, W. E. Smith. ***Scullin.***—G. N. Toops. ***Tulsa.***—W. C. Mundt.

JUNIORS.—***Chandler.***—H. J. Wilkins. ***Muskogee.***—T. Nagel. ***Oklahoma.***—W. A. Gates, W. E. Price. ***Trail.***—J. W. Paret. ***Wagoner.***—J. W. Currey.

OREGON. Total Membership, 100.

MEMBERS.—***Ashland.***—F. H. Walker. ***Clifton.***—W. G. Brown. ***Cottage Grove.***—A. B. Wood. ***Klamath Falls.***—W. W. Patch. ***Medford.***—W. Gerig, W. S. Smith. ***Natron.***—H. I. Randall. ***Pokegama.***—E. T. Abbott. ***Portland.*** C. K. Allen, C. Andersen, E. I. Cantine, D. D. Clarke, F. W. Conn, J. H. Cunningham, R. G. Dieck, F. I. Fuller, J. B. Goodwin, W. H. Graves, G. B. Hegardt, D. C. Henny, W. E. Herring, F. Hesse, G. S. Hewins, E. G. Hopson, J. Q. Jamieson, L. C. Kelsey, G. W. Lilly, J. B. C. Lockwood, C. J. McGonigle, G. C. Mason, J. J. Morrow, J. P. Newell, E. W. Paget, W. R. Phillips, J. S. Polhemus, M. E. Reed, F. C. Schubert, O. E. Stanley, H. A. Sumner, E. A. Taylor, E. B. Thomson, W. R. Weidman, J. T. Whistler. ***The Dalles.***—G. E. Goodwin.

ASSOCIATE MEMBERS.—***Big Eddy.***—J. L. Brownlee, F. W. Saunders, G. A. Sisson. ***Brogan.***—W. S. Collins. ***Burns.***—R. De F. Cooper, M. V Dodge. ***Cascade Locks.***—C. W. Thompson. ***Cottage Grove.***—R. E. Griswold. ***Eagle Point.***—T. F. Boltz. ***Eugene.***—F. G. Frink. ***Hermiston.***—H. D. Newell, J. F. Richardson. ***Klamath Falls.***—G. W. Corrigan. ***Lakeview.***—G. W. Rice. ***Marshfield.***—F. E. Leefe. ***Portland.***—W. W. Amburn, J. G. Beach, G. Boschke, R. Chase, W. D. Clarke, R. H. Corey, J. A. Fouilhoux, L. W. Hall, D. S. Hays, B. R.

Honeyman, G. A. Kyle, O. Laurgaard, E. B. MacNaughton, G. L. Parker, H. E. Plummer, C. W. Raynor, J. A. Sargent, D. H. Sawyer, J. C. Stephens, G. Stubblefield, H. A. Whitney, O. H. Wright. ***Salem.***—J. H. Lewis. ***Vale.***—O. S. Osborn. ***Warrenton.***—C. N. Bennett.

ASSOCIATES.—***Portland.***—J. A. Currey.

JUNIORS.—***Ashland.***—E. C. Weaver. ***Bull Run.***—C. E. Hickok. ***Grants Pass.***—H. C. Ackemann. ***Portland.***—L. A. Andrus, H. B. Coburn, Jr., R. W. Davenport, T. M. Goodrich, C. J. Green, G. Haselton, H. B. Hastings, T. H. Holmes, R. E. Mieth, H. L. Wiley, C. W. Woodruff. ***Salem.***—R. C. Wygant.

PENNSYLVANIA. Total Membership, 509.

HONORARY MEMBERS.—***Bethlehem.***—J. Fritz. ***Philadelphia.***—G. W. Melville.

MEMBERS.—***Allentown.***—H. F. Bascom, L. J. H. Grossart. ***Altoona.***—H. Linton. ***Ambridge.***—R. M. Greene, R. G. Manning. ***Athens.***—C. Kellogg, C. S. Maurice. ***Bangor.***—C. Albertson. ***Beaver Falls.***—C. H. Vaughan, T. S. White. ***Bellevue.***—W. Martin. ***Braeburn.***—G. H. Neilson. ***Brownsville.***—J. B. Bott, D. K. Orr. ***Bryn Mawr.***—T. N. Ely. ***Camp Hill.***—G. W. Ensign. ***Carbondale.***—C. L. Rowland. ***Connellsville.***—J. B. Hogg, G. H. Matthes. ***Cornwall.***—H. Souder. ***Crafton.***—J. S. Haring. ***Darby.***—A. F. Damon, Jr. ***East Downingtown.***—R. I D. Ashbridge. ***Easton.***—H. R. Fehr, F. Firmstone, J. M. Sherrerd. ***Erie.***—B. E. Briggs, J. W. Hughes, J. Supplee. ***Glenshaw.***—F. L. Garlinghouse. ***Greenville.***—W. S. McFetridge, H. T. Porter. ***Harrisburg.***—D. MacAllister, M. D. Pratt, F. H. Snow, W. Whited. ***Huntingdon.***—J. M. Africa. ***Irwin.***—E. G. Smith. ***Jenkintown.***—J. W. Hunter. ***Johnstown.***—C. E. Curtis, E. F. Kenney, G. E. Thackray. ***Lancaster.***—J. B. Rohrer. ***Lansford.***—W. G. Whildin. ***Meadville.***—W. A. Doane. ***New Castle.***—W. G. Price. ***Norristown.***—DeW. P. Pugh. ***Oil City.***—F. M. Towl. ***Philadelphia.***—F. W. Abbott, W. A. Aiken, D. G. Anderson, C. C. Anthony, A. F. Armstrong, W. W. Atterbury, W. F. Ballinger, L. F. Bellinger, G. P. Bland, A. Bonzano, M. F. Bonzano, C. P. Bower, P. F. Brendlinger, H. T. Campion, R. C. Clarkson, F. H. Clement, W. W. Cole, J. F. Cullen, C. G. Darrach, G. E. Datesman, E. F. Dawson, R. G. Develin, C. Dillenbeck, F. C. Dunlap, M. W. Easby, W. Easby, Jr., S. E. Fairchild, Jr., R. Farnham, Jr., W. H. Ford, B. Franklin, W. C. Furber, F. L. Garrison, J. E. Gibson, H. T. Grantham, C. W. Haines, G. B. Harris, S. Harris, E. P. H. Harrison, J. F. Hasskarl, L. M. Haupt, I. W. Hubbard, R. L. Humphrey, W. Hunter, P. S. King, F. C. Kunz, B. B. Lathbury, H. W. Latta, J. W. Ledoux, H. R. Leonard, D. J. Lucas, T. C. McCollom, E. Marburg, C. F. Mebus, J. Meigs, C. M. Mills, S. P. Mitchell, W. A. Moncure, H. G. Morris, J. F. Murray, W. J. Nicolls, J. C. Patterson, C. P. Perkins, M. R. Pugh, H. H. Quimby, C. W. Raymond, S. Rea, D. Reeves, J. T. Richards, W. B. Riegner, S. H. Rippey, P. Roberts, Jr., P. M. Sax, C. C. Schneider, H. A. Schofield, E. M. Scofield, G. M. Scofield, E. F. Smith, H. C. Smith, J. T. Stuart, A. Y. Sundstrom, C. A. Sundstrom, S. M. Swaab, J. E. Swanker, E. B. Temple, J. H. Terry, R. Thayer, E. D. Thompson, S. M. Van Loan, S. M. Vauclain, J. A. Vogelson, I. W. von Leer, T. Voorhees, J. C. Wagner, S. T. Wagner, W. L. Webb, G. S. Webster, W. R. Webster, C. A. Wentworth, J. E. Whitfield, D. H. Whitmer, H. W. Wilson, P. H. Wilson, L. R. Zollinger. ***Phœnixville.***—T. A. Coffin, J. S. Deans. ***Pittsburgh.***—L. J. Affelder, J. A. Atwood, G. P. Baldwin, E. M. Bigelow, J. C. Bland, H. R. Blickle, L. P. Blum, W. C. Boyd, W. Bradford, N. F. Brown, J. N. Chester, E. W. Crellin, R. A. Cummings, W. C. Cushing, G. S. Davison, P. Didier, E. S. Fickes, E. Gerber, G. A. Gilfillan, E. Godfrey, N. M. Hench, R. G. Hengst, N. F. Hopkins, T. H. Johnson, W. M. Judd, W. H. Kennedy, R. Khuen, R. W. Knight, M. Knowles, H. Laub, H. F. Layton, G. M. Lehman, J. K. Lyons, A. B. McGrew, D. W. McNaugher, E. K. Morse, J. C. Neale, C. M. Neeld, J. N. Ostrom, R. B. Perrine, O. R. Pihl, H. S. Prichard, A. R. Raymer, T. Rodd, F. G. Ross, H. B. Rust, W. L. Scaife, A. L. Schultz, L. H. Shoemaker, G. H. Simpson, N. S. Sprague, T. A. Straub, C. Strong, E. Swensson, B. H. Taylor, E. B. Taylor, G. L. Taylor, S. A. Taylor, S. La R. Tone, W. M. Venable, J. W. Walker, E. F. Wendt, G. Westinghouse, F. Wilcox, T. J. Wilkerson, W. G. Wilkins, H. M. Wilson, P. L. Wölfel, J. Wood, R. B. Woodworth, C. L. Wooldridge. ***Pottsville.***—T. M. Lavelle, B. Snyder, Jr. ***Reading.***—E. L. Nuebling, F. S. Stevens. ***Ridgway.***—H. B. Norton. ***Scranton.***—W. McK. Marple, W. A. May, C. C. Rose. ***South Bethlehem.***—G. H. Blakeley, T. C. Clarke, A. L. Colby, F. P. McKibben, F. E. Schall, E. H. Shipman, C. E. Webster, W. L. Wilson. ***State College.***—E. D. Walker. ***Steelton.***—C. A. Alden, F. W. Cohen, T. Earle, L. E. Johnson, G. C. Leidy, C. H. Mercer, J. V. W. Reynders. ***Sunbury.***—G. Nauman. ***Susquehanna.***—O. F. Barnes. ***Swarthmore.***—A. Beardsley. ***Tyrone.***—A. E. Bachert. ***Uniontown.***—W. O. White. ***Upper Darby.***—W. V. Polleys. ***Warren.***—De F. A. Wheelock. ***Wilkes-Barre.***—C. Enzian, R. V. A. Norris, H. S. Smith. ***Wilkinsburg.***—W. C. Hawley, R. A. Pendergrass. ***Williamsport.***—S. T. Hayt, Jr.

ASSOCIATE MEMBERS.—***Altoona.***—G. S. Beal, F. Engström. ***Ambridge.***—J. E. Banks, E. B. Butchers, H. L. Christie, A. L. Lee. ***Beaver Falls.***—H. R. Hortenstine. ***Bethlehem.***—S. A. Becker, J. E. Boatrite, J. H. Brillhart, R. E. Neumeyer, A. J. Warlow. ***Cambridge Springs.***—T. D. Pierce. ***Carlisle.***—C. A. Bingham. ***Chambersburg.***—T. J. Brereton. ***Cheat Haven.***—E. S. Johnson. ***Connellsville.***—F. W. Scheidenhelm. ***Easton.***—M. DeT. Kelley, W. T. Lyle, J. M. Porter. ***Erie.***—C. Olds, L. C. Reynolds. ***Folcroft.***—H. W. Hatton. ***Franklin.***—H. W. Claybaugh, W. A. Van Duzer. ***Glenside.***—A. L. Giles. ***Greencastle.***—W. T. Shaw. ***Greensburg.***—M. Forbes. ***Greenville.***—F. R. S. Layng. ***Harrisburg.***—C. I. Bausher, D. L. Diehl, C. A. Emerson, Jr., S. D. Foster, F. Gannett, C. W. Hardt, R. H. Hosmer, P. Voorhees. ***Holsopple.***—F. W. Claflin. ***Johnstown.*** C. P. Collins, D. T. Corning, V. S. Doebler. ***Kittanning.***—H. H. Garrigues. ***Lancaster.***—F. H. Shaw, J. H. Wickersham. ***Lewisburg.***—W. Frick. ***Lykens.***—W. S. Hanna. ***McKeesport.***—J. M. Peters, J. B. Sweeney. ***Mauch Chunk.***—DeW. C. Fenstermaker. ***Meadville.***—F. W. Strickler. ***New Castle.***—T. A. Gilkey. ***Pencoyd.***—R. E. Sexton. ***Philadelphia.***—O. H. Ammann,

P. S. Baker, C. W. T. Barker, H. C. Berry, D. W. Bliem, H. C. Booz, E. E. Bratton, E. Clark, R. Coe, C. E. Collins, St. G. H. Cooke, F. R. Davis, J. S. Ely, E. M. Evans, L. R. Ferguson, H. T. Fisher, W. Fisher, W. L. Fitzgerald, O. H. Gentner, Jr., W. H. Gravell, C. F. Gross, E. L. Ingram, W. I. Lex, W. P. Linton, W. A. McIntyre, R. Murray, W. T. Newcomb, H. V. B. Osbourn, G. F. Pawling, A. B. Perley, E. G. Perrot, A. C. Pflueger, J. R. Potter, A. C. Prime, R. F. Proctor, E. J. Rights, H. T. Rights, H. V. Schreiber, R. W. Shelmire J. G. Shryock, T. N. Spencer, W. L. Stevenson, W. P. Taylor, A. L. Terry, Jr., C. W. Thorn, H. W. Underwood, C. B. Voynow, G. R. Wood, A. S. Woodle, Jr., H. B. Wrigley. ***Phœnixville.***—S. Gowen, C. W. MacCornack, N. R. McLure. ***Pittsburgh.***—R. Albree, A. R. Archer, A. C. Beeson, M. Burden, F. Burroughs G. H. Clapp, V. R. Covell, G. M. Demorest, J. L. de Vou, C. G. Dunnells, T. Fleming, Jr., E. A. Gibbs, I. D. Goodwin, K. C. Grant, H. A. Greene, J. H. Griffith, G. Gudmundsson, E. D. Harshbarger, C. K. Harvey, A. A. Henderson, E. N. Hunting, W. H. Hyde, J. B. Leeper, J. B. McCord, J. V. McNary, F. S. Merrill, F. L. Metzger, W. E. Mott, G. B. Palmer, A. F. Plock, P. W. Price, H. H. Rankin, J. M. T. Rice, L. J. Riegler, J. K. Scott, E. E. Seyfert, J. Shema, J. L. Stuart, H. R. Thayer, L. D. Tracy, G. C. Urquhart, G. J. Walker, W. D. Wiggins, C. L. Wilcox. ***Pottstown.***—J. Jones. ***Reading.*** E. B. Ulrich. ***St. Marys.***—W. R. Craig. ***Saltsburg.*** A. Smith. ***Schuylkill Haven.*** G. W. Butz. ***Scranton.***—R. D. Richardson, C. K. Smoley. ***Sewickley.***—W. Charnley. ***Somerset.***—J. B. Cameron. ***South Bethlehem.***—L. De V. Conkling, K. E. Hendricks, H. R. St. A. Walters. ***State College.***—P. B. Breneman, R. I. Webber. ***Steelton.***—S. W. Bradshaw, C. B. Ely, W. B. Keim, C. Miller, J. H. Myers, S. H. Noyes. ***Susquehanna.***—E. I. Bowen. ***Swarthmore.***—F. M. Sawyer, J. Taylor, Jr. ***Upper Darby.***—H. S. Farquhar. ***Warren.***—W. A. Wynn. ***Washington.***—O. K. Taylor, Jr. ***Weatherly.***—W. A. Jones. ***Wellsboro.***—S. W. Jackson. ***West Chester.***—W. H. Fulweiler. ***Wilkes-Barre.***—C. R. French, G. G. Jacobosky. ***Wilkinsburg.***—C. L. Fox, E. Hazard, T. D. Lynch. ***Williamsport.***—G. R. Sinnickson. ***York.***—T. T. Heiges.

ASSOCIATES.—***Allentown.***—C. M. Saeger. ***Erie.***—W. C. Olds. ***Overbrook.***—S. Bent. ***Philadelphia.***—J. G. Brown, G. Burnham, Jr., L. V. Clark, A. J. County, H. B. Green, W. G. Hartranft, R. W. Lesley, J. B. Lober, J. P. A. Maignen, A. G. Patton, A. Sommer, J. C. Trautwine, Jr. ***Pittsburgh.***—E. C. Dilworth, C. C. Smith. ***Steelton.***—G. W. Parsons.

JUNIORS.—***Altoona.***—E. D. Tillson. ***Ambridge.***—V. D. Beard, A. F. Boig, E. Querbach. ***Carbondale.***—A. B. Cole. ***Delaware Water Gap.***—L. B. Croasdale. ***East Pittsburgh.***—A. C. Johnston. ***Harrisburg.***—R. J. Colgan. ***Huntingdon.*** C. R. Simpson. ***Lancaster.***—A. H. Kohn. ***Philadelphia.***—H. W. Bloemker, J. W. Calder, L. T. Emory, H. C. Gardner, I. S. Grindrod, E. G. King, H. McClure, W. H. McDowell, J. P. Mudd, S. G. Smith, C. B. Suttle, G. L. Watson. ***Phœnixville.***—R. S. Foulds. ***Pittsburgh.***—W. E. Crane, A. S. Davison, F. Y. Dorrance, F. S. Foulkrod, W. R. Hughes, Jr., C. R. Irvin, W. M. Kinney, C. E. Long, W. V. Scott. ***Reading.***—G. S. Armstrong, Jr. ***South Bethlehem.***—C. A. Gross. ***State College.***—J. R. Lapham. ***Steelton.***—H. S. Battie, K. W. Lemcke. ***Warren.***—E. R. Brann. ***Wilkes-Barre.***—R. Hand, F. C. Wintermute. ***Wilkinsburg.***—B. Fleeger, A. Richards.

FELLOWS.—***Philadelphia.***—E. W. Clark.

RHODE ISLAND. Total Membership, 45.

MEMBERS.—***Arlington.***—H. N. Francis. ***Narragansett Pier.***—W. Kent. ***Newport.***—J. P. Cotton, W. H. Lawton, J. W. G. Walker. ***Pawtucket.***—G. A. Carpenter. ***Providence.***—J. S. Browne, W. D. Bullock, C. F. Chase, O. F. Clapp, J. V. Dart, J. R. Freeman, S. M. Gray, J. E. Hill, G. H. Leland, E. W. Ross, O. P. Sarle, E. W. Shedd, J. H. Shedd, H. E. Sherman, W. H. G. Temple, E. B. Weston, I. S. Wood. ***Woonsocket.***—J. W. Ellis.

ASSOCIATE MEMBERS.—***Providence.***—H. W. Ballou, N. D. Benson, G. F. Hosmer, S. F. Nolan, L. H. Peabody, P. S. Perkins, W. B. Wood. ***Westerly.***—T. McKenzie.

JUNIORS.—***Middletown.***—C. H. Ward, 2d. ***Pawtucket.***—H. F. Esten. ***Providence.***—H. B. Edmundson, R. E. Hutchins, H. E. Miller, H. B. O'Neil, J. Price, O. W. Rackle, H. A. Sweetland, E. W. Wall, J. Wilmot. ***Rumford.***—M. H. S. Affleck. ***Woonsocket.***—J. W. McCaffrey.

SOUTH CAROLINA. Total Membership, 15.

MEMBERS.—***Charleston.*** J. P. Allen, G. P. Howell, J. V. Rockwell, R. Whitford. ***Columbia.***—J. McNeal, G. E. Shand, C. C. Wilson. ***Greenville.***—P. M. Feltham, J. E. Sirrine. ***Greenwood.***—T. W. Cothran. ***Waterloo.***—H. C. Banks.

ASSOCIATE MEMBERS.—***Charleston.*** J. H. Dingle, S. C. Dunlop. ***Greenville.***—W. D. Dent, L. P. Slattery.

SOUTH DAKOTA. Total Membership, 9.

MEMBERS.—***Pierre.***—S. H. Lea. ***Vermillion.***—A. B. McDaniel.

ASSOCIATE MEMBERS.—***Belle Fourche.***—F. C. Magruder. ***Brookings.***—H. M. Derr. ***Fort Meade.***—J. H. Williams. ***Lead.***—B. C. Yates. ***Newell.***—O. McDermith. ***Orman.***—A. W. Walker.

JUNIORS.—***Aberdeen.***—R. B. Easton.

TENNESSEE. Total Membership, 74.

MEMBERS.—***Chattanooga.*** H. S. Bosler, J. A. Fairleigh, W. D. Jenkins, H. F. Juengst. D. H. Wood. ***Etowah.***—G. K. McCormick. ***Grand View.***—C. P. Yeatman. ***Guild.***—G. F. Rowell. ***Jackson.***—H. P. Farrar. ***Knoxville.***—W. W. Carson. ***Memphis.***—W. E. Ayres, E. H. Bowser, A. B. Diehr, W. M. Gardner, J. Z. George, W. W. Hayden, J. H. Haylow, F. H. Hilliard, L. Y. Kerr, H. N. Pharr, W. F. Schulz, T. H. Tutwiler. ***Nashville.***—H. Burgess, A. J. Dyer, W. F. Foster, H. M. Gould, H. M. Jones, E. C. Lewis, C. A. Locke, H. McDonald, J. S. Walker, F. S. Washburn.

ASSOCIATE MEMBERS.—***Chattanooga.*** E. E. Betts, W. H. Converse, H. B. W. Howie, J. H. Randolph, Jr., E. C. Soper, W. S. Winn. ***Chilhowee.***—G. M. Bassell, R. S. Peotter. ***Clarksville.***—C. F. Chappell. ***Copperhill.***—W. I. Nolen. ***Guild.***—C. H. Tisdale. ***Harriman.***—J. R. Fain. ***Johnson City.***—J. E. Shepardson. ***Lewisburg.***—W. Watson. ***Memphis.***—D. M. Brock, P. D. Fuqua, L. R. Gifford, E. L. Harrison, L. L. Hidinger, H. N. Howe, A. E. Morgan, J. A. Omberg, Jr., C. E. Shearer, A. F. Stanford. ***Nashville.***—G. Jackson. ***Parksville.***—R. H. Anderson, F. W. Barnes, Jr., J. G. Munson. ***Sewanee.***—B. LeF. Coulson. ***South Pittsburg.***—E. N. Floyd.

JUNIORS.—***Chattanooga.***—W. B. Clift, C. A. Lyerly, Jr. ***Chilhowee.***—C. E. Ramser, C. E. Stilson. ***Jackson.***—M. S. Harvey. ***Knoxville.***—R. L. Morrison. ***Memphis.***—J. J. Crotty, G. W. Miller, R. L. Rolfe, A. B. Segur. ***Nashville.***—H. H. Cartwright, W. F. Winton.

TEXAS. Total Membership, 93.

MEMBERS.—***Altura.***—W. G. Russell. ***Austin.***—T. U. Taylor. ***Beaumont.***—C. L. Scherer. ***China.***—C. W. Rollins. ***College Station.***—J. C. Nagle. ***Corsicana.***—H. G. Johnston. ***Dallas.*** C. H. Chamberlin, T. H. Jackson, O. H. Lang, R. C. Smead, B. S. Wathen. ***El Paso.***—J. L. Campbell, W. W. Follett, J. A. French, W. M. Reed, F. Teichman, F. H. Todd. ***Fort Worth.***—J. B. Hawley, W. B. King. ***Galveston.***—E. I. Brown, C. L. Crandall, E. M. Hartrick, W. P. Parker, L. W. Stubbs. ***Houston.***—W. M. Archibald, E. B. Cushing, J. M. Howe, H. F. Jonas, M. Morris, Jr. ***Marshall.***—H. DeW. Smith. ***San Antonio.***—R. H. Gresham. ***Stephenville.***—E. J. Nichols. ***Terrell.***—L. W. Wells.

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JUNIORS.—***Austin.***—S. P. Finch, R. G. Tyler. ***Corpus Christi.***—C. F. K-M. von Blücher. ***Dallas.***—W. J. Powell. ***Fort Worth.***—C. P. Chester, J. K. Grannis, A. C. Kellersberger. ***Galveston.***—N. T. Blackburn, C. F. Bornefeld. ***Houston.***—J. H. Bringhurst, C. J. Howard. F. M. Thomson. ***Marshall.***—R. L. Holmes. ***Paris.***—W. A. Burton, M. Hannah. ***Pecos.***—L. W. Anderson. ***San Antonio.***—A. P. Rollins.

UTAH. Total Membership, 31.

MEMBERS.—***Manti.***—H. S. Kerr. ***Ogden.***—A. F. Parker. ***Provo.***—P. N Nunn. ***Salt Lake City.***—W. Ashton, G. M. Bacon, F. E. Baxter, A. F. Doremus, F. C. French, R. C. Gemmell, R. B. Ketchum, M. M. Murtaugh, A. M. Nelson.

ASSOCIATE MEMBERS.—***Logan.***—R. Bullen. ***Myton.***—H. C. Means. ***Provo.***—V. Y. Davoud. R. F. Ewald, C. S. Jarvis, J. L. Lytel. ***Salt Lake City.***—C. F. Brown, R. K. Brown, J. Duder, R. P. Hovey, H. S. Kleinschmidt, E. C. LaRue, R. R. Lyman, H. W. Sheley, M. Sullivan, P. L. Williams, Jr.

JUNIORS.—***Ogden.***—D. H. Brown. ***Provo.***—G. M. Gilkison, D. R. Weber.

VERMONT. Total Membership, 7.

MEMBERS.—***Burlington.***—J. W. Elliott, F. O. Sinclair. ***Rutland.***—J. C. Irwin. ***St. Johnsbury.***—D. Williams.

ASSOCIATE MEMBERS.—***Northfield.***—A. E. Winslow. ***Orleans.***—L. L. Gay.

JUNIORS.—***Rutland.***—L. W. Abrons.

VIRGINIA. Total Membership, 79.

MEMBERS.—***Blacksburg.***—L. S. Randolph. ***Cascade.***—A. V. Sims. ***Dante.***—W. D. Tyler. ***Fredericksburg.***—G. B. Strickler. ***Harrisonburg.***—N. W. Davis. ***Houston.***—H. C. Derrick. ***Leesburg.***—H. H. Trundle, C. O. Vandevanter. ***Lexington.***—D. C. Humphreys. ***Newport News.***—W. A. Post. ***Norfolk.***—S. Carter, L. M. Cox, H. Fernstrom, F. F. Harrington, L. M. Lyon, F. L. Nicholson, E. B. Noyes, M. M. Patrick. ***Petersburg.***—R. D. Budd, J. W. Hays. ***Portsmouth.***—E. A. Frink. ***Pulaski.***—G. H. Derrick. ***Richmond.***—D. Axtell, M. J. Caples, H. Frazier, E. T. D. Myers, Jr., F. W. Scarborough, S. H. Yonge. ***Roanoke.***—A. Bruner, C. S. Churchill, W. W. Coe, J. E. Crawford, J. A. Davenport, J. R. Schick, C. Silliman, G. A. Tretter, C. C. Wentworth, W. P. Wiltsee. ***Waynesboro.***—W. A. Pratt. ***Wenonda.***—J. A. Hall. ***Zion.***—G. H. Browne.

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ASSOCIATES.—***Richmond.***—C. W. Bradley, G. O. Tenney.

JUNIORS.—***Bandy.***—R. H. Smith, Jr. ***Norfolk.***—P. J. Bean, N. Hughes, W. Mahone, Jr. ***Richmond.***—H. R. Messer. ***Roanoke.***—C. Massei. ***Yorktown.***—W. D. Cater.

WASHINGTON. Total Membership, 131.

MEMBERS.—***Bellingham.***—J. J. Donovan. ***Bremerton.***—E. H. Brownell, F. W. D. Holbrook. ***Clarkston.***—R. A. Foster, S. S. Philbrick. ***Ellensburg.***—E. H. Baldwin. ***Fort Worden.***—S. D. Mason. ***North Yakima.***—T. A. Noble. ***Olympia.***—W. J. Roberts, C. H. Sweetser. ***Palmer.***—H. A. Hall. ***Richmond Beach.***—M. Chase. ***Seattle.***—N. A. Carle, H. M. Chittenden, J. M. Clapp, B. D. Dean, A. H. Dimock, A. S. Downey, C. E. Fowler, A. H. Fuller, J. L. Hall, S. H. Hedges, J. I. Horrocks, R. Howes, E. B. Hussey, J. Jacobs, J. D. MacVicar, E. J. McCaustland, D. W. McMorris, A. W. Münster, R. H. Ober, H. K. Owens, A. O. Powell, W. B. Ruggles, F. F. Sinks, R. H. Thomson, H. H. Wolff. ***Spokane.***—H. C. Allen, A. A. Booth, O. S. Bowen, T. H. Croswell, A. G. Holt, U. B. Hough, A. McC. Lupfer, C. S. MacCalla, S. A. McCoy, P. Mogensen, W. E. Moore, F. L. Pitman, J. C. Ralston, B. C. Riblet, F. McC. Sylvester. ***Sumner.***—W. P. Wood. ***Sunnyside.***—E. McCulloh, I. Watson. ***Tacoma.***—B. L. Crosby. ***Toppenish.***—J. W. Martin.

ASSOCIATE MEMBERS.—***Bellingham.***—E. C. Macy. ***Blaine.***—E. B. Day. ***Bremerton.***—H. E. Squire, R. M. Warfield. ***Centralia.***—C. De La P. Atterbury. ***Chehalis.***—W. H. Allen. ***Fallbridge.***—H. M. Harps. ***Fort Flagler.***—J. C. Phillips. ***Hanford.***—G. T. Petheram. ***Kelso.***—P. A. G. Tilmont. ***Leavenworth.***—A. H. Sylvester. ***Mabton.***—C. B. Cox. ***Moses Lake.***—C. C. Ward. ***North Yakima.***—W. N. Collier, H. J. Doolittle, E. H. Elder, D. Hays. ***Olympia.***—H. L. Gray. ***Republic.***—F. H. Richardson. ***Seattle.***—H. J. M. Baker, C. A. Burnette, B. E. Corlett, L. M. Grant, J. A. Jackson, C. B. Lamont, S. Murray, A. T. Nelson, S. B. Phillips, T. E. Phipps, C. H. Reeves, H. R. Robbins, A. W. Sargent. ***Spokane.***—R. L. Alexander, A. D. Butler, M. A. Butler, W. H. Fisher, C. H. Jabelonsky, E. A. Keys, T. J. Klossowski, M. Macartney, W. H. Phillips, G. L. Sawyer. ***Sumner.***—W. D. Shannon. ***Tacoma.***—C. L. Creelman, C. F. Healey, J. E. Moody, W. C. Raleigh. ***Toledo.***—P. J. Cleaver. ***Vancouver.***—E. J. Dent. ***Wapato.***—J. H. Best. ***Wenatchee.***—H. L. McDonald, J. W. Sussex.

ASSOCIATES.—***Seattle.***—O. P. M. Goss, J. W. Miller.

JUNIORS.—***Bremerton.***—H. L. Muchemore, H. F. Scholtz. ***Fort Ward.***—P. H. Ottosen. ***Seattle.***—W. W. Clifford, H. J. Flagg, V. H. Garvey, F. M. Johnson, F. A. Kittredge, T. G. McCrory, J. C. Rathbun, F. M. Smith, R. E. Smith, W. D. Smith, G. R. Strandberg. ***Sedro Woolley.***—J. B. Warrack. ***Spokane.***—J. W. Cunningham, B. J. Garnett, W. Le R. Maloney, C. U. Smith. ***Sunnyside.***—W. L. Rowe.

WEST VIRGINIA. Total Membership, 37.

MEMBERS.—***Berkeley Springs.***—B. S. Randolph. ***Bluefield.***—S. H. Meem. ***Charleston.***—S. P. Baird, A. M. Scott. ***Clarksburg.*** D. D. Britt, T. M. Jackson. ***Elkins.***—J. F. Healy. ***Gary.***—H. N. Eavenson. ***Morgantown.*** S. D. Brady. ***New Cumberland.*** C. E. Grafton, J. C. Thomas. ***New Martinsville.***—F. D. Holbrook. ***Parkersburg.*** W. McL. Hall. ***Wheeling.***—F. B. Duis, F. A. Hastings, J. A. McDonough.

ASSOCIATE MEMBERS.—***Bluefield.***—G. Dunglinson, Jr. ***Charleston.*** R. P. Black, C. E. McCoy. ***Huntington.***—T. C. Marshall, F. O. Renshaw. ***Kenova.*** F. P. Turner. ***New Cumberland.***—L. O. Barker, Jr. ***New Martinsville.***—C. R. Andrew. ***Parkersburg.***—J. P. Horstman, B. F. Stewart, Jr. ***Stanaford.*** C. M. Binford. ***Wheeling.***—F. W. Altstaetter, G. B. Bebout, W. N. Dambach, R. Hazlett. ***Williamson.***—W. F. Kirby.

ASSOCIATES.—***Charleston.***—W. D. Sell.

JUNIORS.—***Morgantown.***—R. P. Davis. ***Newburg.***—A. V. Vanneman. ***Princeton.***—H. E. Hines. ***Sheperdstown.***—C. W. Schedler, Jr.

WISCONSIN. Total Membership, 44.

HONORARY MEMBERS.—***Milwaukee.***—D. J. Whittemore.

MEMBERS.—***Berlin.***—E. L. Walker. ***La Crosse.***—W. A. Thompson. ***Madison.***—D. W. Mead, W. D. Pence, L. S. Smith. ***Milwaukee.***—G. H. Benzenberg, W. F. Carr, R. E. Newton, C. J. Poetsch, W. J. Sando, L. E. Strothman. ***Reserve.***—G. M. Huss.

ASSOCIATE MEMBERS.—***Madison.***—L. R. Balch, G. J. Davis, Jr., C. M. Larson, W. E. Miller, C. V. Seastone, C. B. Stewart, C. Thuringer, F. E. Turneaure, L. F. Van Hagan, C. R. Weidner, C. P. Winslow. ***Milwaukee.***—A. C. Bell, L. E. Bogen, J. C. Davis, J. F. Jackson, L. D. Williams. ***Sheboygan.***—E. F. Sinz. ***South Milwaukee.***—W. M. Rosewater. ***Waukesha.***—C. Berry.

ASSOCIATES.—***North Milwaukee.***—T. R. Brown.

JUNIORS.—***Madison.***—D. E. Davis, F. W. Doolittle, R. M. Feustel, J. G. Hirsch, L. P. Jerrard, E. C. Stocker. ***Milwaukee.***—G. E. Kahn, G. C. Newton. ***Sheboygan.***—H. F. Porter. ***Superior.***—T. O. Gilland.

FELLOWS.—***Milwaukee.***—S. M. Green.

WYOMING. Total Membership, 15.

MEMBERS.—***Cheyenne.***—H. B. Patten. ***Evanston.***—W. Newbrough. ***Laramie.***—R. D. Stewart. ***Powell.***—C. P. Williams. ***Sheridan.***—E. Gillette.

ASSOCIATE MEMBERS.—***Cheyenne.***—C. D. Avery, F. G. Skinner, R. D. Tyler. ***Germania.***—G. W. Zorn. ***Pathfinder.***—H. D. Comstock. ***Powell.***—E. E. Sands. ***Sheridan.***—E. L. Clarke.

JUNIORS.—***Cody.***—H. F. Bell. ***Powell.***—R. W. Hazen, A. P. Smyth.

CENTRAL AMERICA.

COSTA RICA. Total Membership, 4.

MEMBERS.—***San José.***—H. Hardy, L. Matamoros. ***Toro Amarillo.***—P. W. Chamberlain.

JUNIORS.—***Limon.***—N. Benedict.

GUATEMALA. Total Membership, 3.

ASSOCIATE MEMBERS.—***Guatemala.***—S. Vilar y Boy.

JUNIORS.—***Barrios.***—A. I. Stiles, P. E. Tillit.

NICARAGUA. Total Membership, 1.

MEMBERS.—***Managua.***—J. C. Wiest.

PANAMA. Total Membership, 50.

MEMBERS.—***Corozal.***—H. O. Cole, W. L. Thompson, J. M. G. Watt, S. B. Williamson. ***Culebra.***—L. D. Cornish, G. W. Goethals, H. Goldmark, H. F. Hodges, T. E. L. Lipsey, E. Schildhauer, W. L. Sibert. ***Empire.***—A. S. Zinn. ***Gatun.***—C. Harding, J. P. Jervey, L. L. Jewel, B. Johnson, G. M. Wells. ***Panama.***—R. M. Arango, J. G. Holcombe.

ASSOCIATE MEMBERS.—***Ancon.***—A. P. Crary. ***Bocas del Toro.***—A. G. Robertson. ***Corozal.***—F. Cotton, A. R. James, W. Rowland. ***Cristobal.***—F. Mears, C. Nixon, F. C. Stanton. ***Culebra.***—F. H. Cooke, T. B. Mönniche, H. H. Rousseau, F. E. Sterns. ***Gatun.***—G. C. Dobson, C. P. Fortney, N. M. Johnson, C. E. Langley, J. T. Neely, W. H. Rose. ***Las Cascadas.***—W. D. Stanton. ***Panama.***—R. W. Hebard.

JUNIORS.—***Balboa.***—J. R. Pemberton, W. J. Spalding. ***Bocas del Toro.***—I. O. Gibble. ***Corozal.***—H. W. Bluhm. ***Cristobal.***—E. B. Nelson. ***Culebra.***—A. R. Brown, V. A. Eberly, O. E. Malsbury, J. G. Steese. ***Gatun.***—H. F. Bronson, H. E. Snyder.

GEOGRAPHICAL DISTRIBUTION

SOUTH AMERICA.

ARGENTINE REPUBLIC. Total Membership, 15.

MEMBERS.—***Bahia Blanca.***—C. Anthony, Jr. ***Buenos Aires.***—W. L. Brown, F. Foster, A. B. Lea, C. E. d'Ornellas, C. Wauters. ***Colonia Alvear.***—G. A. Lange. ***Cordoba.***—C. C. Lewis.

ASSOCIATE MEMBERS.—***Bahia Blanca.***—H. Williamson. ***Buenos Aires.***—A. A. Agramonte, E. I. Clawiter, C. L. Nelson, P. Smith. ***Cordoba.***—E. T. E. Miller. ***Mendoza.***—J. J. Corti.

BOLIVIA. Total Membership, 3.

MEMBERS.—***La Paz.***—J. Pierce-Hope.

ASSOCIATE MEMBERS.—***Oruro.***—W. L. Gibson.

JUNIORS.—***Oruro.***—D. Hubbard.

BRAZIL. Total Membership, 22.

MEMBERS.—***Manāos.***—J. Y. Bayliss, H. F. Dose, J. M. Robinson. ***Rio de Janeiro.***—J. A. dos Santos, W. G. McConnel, C. de Sá Rabello, H. C. Ripley. ***Santos.***—W. Huggins. ***São Paulo.***—S. F. Shaw, V. da Silva Freire, W. N. Walmsley.

ASSOCIATE MEMBERS.—***Bello Horizonte.***—L. Baeta-Neves. ***Itacoatiara.***—J. H. Digby. ***Manāos.***—S. S. Bunker, E. B. Karnopp, M. V. Powell. ***Porto Velho.***—F. S. Weston. ***Rio de Janeiro.***—D. H. Campbell, J. Pires do Rio, T. P. Stevenson, Jr. ***São Paulo.***—V. Le R. Havens.

JUNIORS.—***Rio de Janeiro.***—H. C. Frisbie.

CHILI. Total Membership, 4.

MEMBERS.—***Antofagasta.*** E. H. Drury. ***Santiago.***—J. Tonkin Thomas. ***Valparaiso.*** E. B. Budge.

ASSOCIATE MEMBERS.—***Santiago.***—W. B. Leane.

COLOMBIA. Total Membership, 5.

MEMBERS.—***Bogota.***—G. A. Ritchie. ***Cali.***—R. A. Sálas. ***Medellin.***—G. S. Walsh.

ASSOCIATE MEMBERS.—***Cali.***—H. J. Eder. ***Girardot.***—A. de la Torre.

ECUADOR. Total Membership, 2.

MEMBERS.—***Guayaquil.***—A. S. Hobby.

ASSOCIATE MEMBERS.—***Guayaquil.***—H. F. Howe.

PERU. Total Membership, 8.

MEMBERS.—***Arequipa.***—T. A. Corry. ***Lima.***—A. B. Bentzon.

ASSOCIATE MEMBERS.—***Arequipa.***—J. A. Arce. ***Gayllarisquisga.*** W. K. Runyon. ***Lima.***—F. Carbajal, R. Ferradas, C. W. Sutton. ***Oroya.***—J. H. Burgoyne, Jr.

URUGUAY. Total Membership, 1.

ASSOCIATE MEMBERS.—***Montevideo.***—V. B. Sudriers.

VENEZUELA. Total Membership, 1.

ASSOCIATE MEMBERS.—***Maracaybo.***—P. J. Rojas.

WEST INDIA ISLANDS.

CUBA. Total Membership, 52.

MEMBERS. ***Camagüey.*** A. L. Phillips. ***Ceballos.*** -P. B. Windsor. ***Havana.***- T. T. Allard, J. F. Case, M. A. Coroalles, C. C. FitzGerald, F. L. Getman, H. E. Hyde, J. A. McNicol, M. A. Smith, D. A. Watt. ***Matanzas.*** -Y. Polledo. ***Sagua la Grande.*** G. P. Morrill. ***Santiago de Cuba.***—E. J. Chibas, J. H. H. Muirhead.

ASSOCIATE MEMBERS.—***Calimete.***—P. A. Suarez y Cordoves. ***Camagüey.***—J. M. Farrin, N. P. Turner. ***Felton.***—A. C. Reed. ***Firmeza.***—A. W. Gaumer. ***Guantanamo.***—J. W. Hortenstine, S. C. Houser, R. Whitman. ***Havana.***—J. M. Babé, A. Durant, T. Frasquieri y Regueifero, F. J. Gaston y Rosell, T. L. Huston, C. E. Martinez y Reugifo, J. D. Montero, F. A. Snyder, J. R. Villalon. ***Sagua la Grande.***—J. M. Bischoff, G. C. Brown, W. A. Hunicke, E. M. Rosher, E. R. Williams. ***Santa Clara.***—G. G. Fischer. ***Santiago de Cuba.*** -S. A. Barratt, G. W. Pfeiffer.

JUNIORS. ***Cienfuegos.*** -A. Castillo y Grau. ***Felton.*** -W. H. McCandliss. ***Guantanamo.***—R. L. Lindsay, G. C. Peterson. ***Havana.***—G. A. Dubois, R. S. Giquel, R. A. Martinez, H. H. Rennell, R. J. Torralbas, M. Villa, R. S. Webster. ***Santa Clara.***—J. J. Manzanilla y Carbonell.

DOMINICA. Total Membership, 1.

ASSOCIATE MEMBERS.—***Canefield.***—A. H Green.

HAITI. Total Membership, 4.

MEMBERS.—***Port au Prince.***—F. W. Andros.

ASSOCIATE MEMBERS. ***Port au Prince.*** P. B. Easterbrooks. ***Cape Haitien.*** M. Wassner.

JUNIORS.—***Port au Prince.***—C. A. Bock.

JAMAICA. Total Membership, 3.

MEMBERS.—***Kingston.***—C. J. Thornton.

ASSOCIATE MEMBERS.—***Kingston.***—J. H. Dodd. ***Richmond.***—J. M. Fletcher.

PORTO RICO. Total Membership, 18.

MEMBERS.—***Central Aguirre.***—C. L. Carpenter. ***Guayama.***—J. W. Beardsley, W. W. Schlecht. ***Ponce.***—M. V. Domenech. ***San Juan.***—J. A. Canals, H. C. DeLano.

ASSOCIATE MEMBERS.—***Bayamón.***—A. A. Van Petten. ***Central Aguirre.***—F. Pace. ***Guayama.***—J. M. Giles. ***Juana Diaz.***—L. V. N. Branch, N. R. Willard. ***San Juan.***—C. del Valle Zeno.

JUNIORS.—***Bayamón.***—A. C. Toll. ***Guayama.***—M. J. Backus. ***Juana Diaz.***—L. J. Davila, A. S. Lucchetti-Otero. ***San Juan.***—O. Y. Leonard, R. M. Merriman.

SANTO DOMINGO. Total Membership, 9.

MEMBERS.—***La Romana.***—V. A. Harris. ***Santo Domingo.***—W. H. Balch, H. F. D. Burke, J. L. Mann.

ASSOCIATE MEMBERS. -***Azua.***—L. M. Huntington. ***Puerto Plata.***—J. T Collins, A. Levy.

JUNIORS.—***Santo Domingo.***—A. P. Ackerman, J. H. Stone.

TRINIDAD. Total Membership, 1.

ASSOCIATE MEMBERS.—***Port of Spain.***—L. J. Proctor.

EUROPE.

AUSTRIA. Total Membership, 3.

MEMBERS.—***Vienna.***—C. Redlich, F. E. von Emperger, E. A Ziffer.

DENMARK. Total Membership, 2.

MEMBERS.—***Charlottenlund.***—M. I. Nyeboe.

ASSOCIATE MEMBERS.—***Copenhagen.***—H. T. Forchhammer.

FRANCE. Total Membership, 7.

CORRESPONDING MEMBERS.—***Paris.***—E. Pontzen.

MEMBERS.—***Nice.***—J. H. Johnston. ***Paris.***—E. Budge, J. W. Kitchin, J. H. Pope.

ASSOCIATE MEMBERS.—***Paris.***—S. D. Brown, A. L. Jacobson.

GERMANY. Total Membership, 6.

CORRESPONDING MEMBERS.—***Hamburg.***—C. O. Gleim.

MEMBERS.—***Berlin.***—R. Bassel. ***Cologne.***—F. W. Lehnartz. ***Dresden.***—G. W. Gehler. ***Munich.***—M. de T. e Argollo.

ASSOCIATE MEMBERS.—***Berlin.***—A. Jordahl.

GREAT BRITAIN. Total Membership, 48.

HONORARY MEMBERS.—***London, Eng.***—D. Fox, W. H. White.

MEMBERS.—***Birmingham, Eng.***—H. P. Raikes. ***Edinburgh, Scotland.***—J. H. Cunningham. ***Farnham, Eng.***—E. H. Hurry. ***Glasgow, Scotland.***—W. Brown, A. Hunter. ***Hitchin, Eng.***—D. Simson. ***Ightham, Eng.***—J. R. Bell. ***London, Eng.***—R. Adam, R. Ballard, R. T. Bayliss, W. H. Booth, A. N. Connett, A. G. Glasgow, J. W. Grimshaw, H. P. Hawksley, R. Hawxhurst, Jr., H. C. Hoover, R. W. Hornsby, J. W. Jacomb-Hood, Z. E. Knapp, F. V. T. Lee, J. A. McDonald, C. F. Marsh, O. J. Marstrand, H. S. Maxim, E. W. Moir, J. P. O'Donnell, J. Orange, F. Palmer, J. E. Selander, M. E. Yeatman. ***Manchester, Eng.***—W. H. Hunter. ***Newcastle-upon-Tyne, Eng.***—J. M. Moncrieff.

ASSOCIATE MEMBERS.—***Ashford, Eng.***—P. à M. Parker. ***Bradford, Eng.***—J. A. Orrell. ***Glasgow, Scotland.***—G. Moncur. ***London, Eng.***—J. Abella, C. D. Drew, J. A. Ely, G. D. B. Turner. ***Widnes, Eng.***—P. M. Pritchard.

ASSOCIATES.—***London, Eng.***—W. A. Brown.

JUNIORS.—***Birmingham, Eng.***—G. B. G. Hull. ***Glasgow, Scotland.***—R. M. Smith. ***Hull, Eng.***—E. G. Walker. ***London, Eng.***—R. Tappan.

ITALY. Total Membership, 2.

MEMBERS.—***Alassio.***—H. S. Haines. ***Rome.***—L. Luiggi.

NETHERLANDS. Total Membership, 1.

MEMBERS.—***Delft***—R. P. J. Tutein-Nolthenius.

NORWAY. Total Membership, 2.

ASSOCIATE MEMBERS.—***Christiania.***—A. Gundersen, G. H. Vedeler.

RUSSIA. Total Membership, 7.

MEMBERS.—***Caucasus.***—T. S. Shmeleff. ***St. Petersburg.***—S. de Kareischa, S. P. Maximoff. ***Tzarskoé Selo.***—V. E. Timonoff.

ASSOCIATE MEMBERS.—***Petersburg.***—M. Nikolitch. ***St. Petersburg.***—E. E. Skorniakoff.

JUNIORS.—***Warsaw.***—A. Mischke.

SPAIN. Total Membership, 1.

MEMBERS.—***Barcelona.***—J. Tintorer y Giberga.

SWEDEN. Total Membership, 3.

ASSOCIATE MEMBERS.—***Göteborg.***—J. K. Selmer. ***Malmo.***—G. V. Dieden. ***Stockholm.***—I. Kreuger.

SWITZERLAND. Total Membership, 1.

MEMBERS.—***Zurich.***—K. E. Hilgard.

GEOGRAPHICAL DISTRIBUTION

AFRICA.

Total Membership, 9.

MEMBERS.— ***Buluwayo, Rhodesia.***—C. Corner. ***Germiston, Transvaal.***—A. W. Stockett. ***Grahamstown, Cape Colony.***—E. Grubb. ***Grootfontein, German Southwest Africa.***—T. Tönnesen. ***Johannesburg, Transvaal.***—J. Orr.

ASSOCIATE MEMBERS.—***Bethlehem, Orange River Colony.***—W. M. Homan. ***Britstown, Cape Colony.***—J. T. B. Gellatly. ***Cradock, Cape Colony.***—R. J. Van Reenen. ***Kinshasa, Congo Belge.***—W. J. Millard.

ASIA.

CHINA. Total Membership, 21.

MEMBERS.—***Chinwangtao.***—R. A. McConaghy. ***Kalgan.*** K. Y. Kwong. ***Nanking.***—T. W. T. Tuckey. ***Peking.***—C. D. Jameson, T. Y. Jeme. ***Shanghai.***—E. J. Müller. ***Tientsin.***—T. H. Handbury. ***Yunnanfu.***—W. S. Dawley.

ASSOCIATE MEMBERS.—***Canton.***—R. C. Johnson, C. S. Paget. ***Foochow.***—E. F. Black. ***Hankow.***—H. E. Baker. ***Ichang.***—T. C. Yen. ***Nanking.***—T. J. Bourne. ***Shanghai.***—W. H. Dietrich, T. A. Ross. ***Tientsin.***—J. C. Vliegenthart, W. R. Wilson.

JUNIORS.—***Canton.***—P. Soo-Hoo. ***Shanghai.***—T. C. Sun. ***Weihsien.***—H. E. Chandler.

INDIA. Total Membership, 10.

MEMBERS.—***Bankipore.***—J. Leitch. ***Lahore.***—C. Lall. ***Madras.*** F. J. E. Spring. ***Mandalay.***—L. Mackintosh. ***Trichur.***—G. E. Browning.

ASSOCIATE MEMBERS. ***Bombay.***—G. T. Mawson. ***Calcutta.*** -E. Brook-Fox, R. H. Sears. ***Patiala.***—C. W. Bowles.

JUNIORS.—***Poona City.***—S. R. Bhâgwat.

JAPAN. Total Membership, 26.

MEMBERS.—***Kobe.***—T. Endo, N. Shiraishi. ***Kyoto.***—U. Ogawa, S. Tanabe. ***Shimotsuke.***—M. Otagawa. ***Tokyo.***—I. Hiroi, H. Inagaki, C. Kadono, S. Kondo, T. Kondo, T. Kurashige, M. Sengoku, T. Tsuji, J. Yamaguchi. ***Yokohama.***—A. J. Bowie.

ASSOCIATE MEMBERS.—***Gunbaken.***—Y. Wada. ***Kumamoto.***—T. Kawaguchi. ***Osaka.***—S. Sekiba. ***Sendai.***—C. Oinouye. ***Takow.***—E. Watanabe. ***Tokyo.***—A. Awoyana, T. Chiba, K. Ichinose, M. Kabashima. ***Yokohama.***—R. F. Moss.

ASSOCIATES.—***Kyoto.***—K. Futami.

PHILIPPINE ISLANDS. Total Membership, 50.

MEMBERS.—***Manila.***—O. D. Filley, A. Gideon, L. F. Goodale, C. E. Gordon, H. L. Higgins, C. W. Hubbell, O. L. Ingalls, C. W. Kutz, W. B. Poland, C. M. Pritchett, W. H. Robinson, E. P. Shuman, E. S. von Piontkowski, W. H. Waugh, C. G. Wrentmore. ***Zamboanga.***—P. S. Bond.

ASSOCIATE MEMBERS.—***Cebu.***—H. F. Cameron. ***Corregidor.***—C. C. Morris. ***Dumaguete.***—W. H. Taylor. ***Manila.***—J. H. Ayres, C. Bradshaw, W. C. Bunnel, W. L. Gordon, C. J. Hogue, C. W. Keith, W. Kelly, H. P. Linnell, M. J. McDonough, H. A. Raider, R. W. Randolph, H. I. Shoemaker, E. P. Thompson.

ASSOCIATES.—***Manila.***—G. G. Stroebe.

JUNIORS.—***Albay.***—C. G. Morrison. ***Cagayan.***—J. W. Graham. ***Manila.***—J. L. Brennan, C. O. Brown, R. J. Buck, G. E. Burnham, A. W. Bushell, J. C. Carpenter, H. W. Corp, G. W. Davis, E. L. Driggs, C. L. Hall, W. L. Hemphill, E. L. Lundgren, N. R. Macklem, R. S. Swinton. ***Zamboanga.***—V. R. Stirling.

STRAITS SETTLEMENTS. Total Membership, 2.

MEMBERS.—***Singapore.***—S. Tomlinson.

ASSOCIATE MEMBERS.—***Singapore.***—H. M. Butterfield.

AUSTRALASIA.

Total Membership, 27.

MEMBERS.—***Adelaide, Australia.***—A. B. Moncrieff. ***Brisbane, Australia.***—J. B. Henderson, E. J. T. Manchester. ***Charleston, Australia.***—A. S. Frew. ***Christchurch, New Zealand.***—C. J. R. Williams. ***Melbourne, Australia.***—J. M. Coane, T. W. Fowler, G. Higgins, M. E. Kernot, H. C. Mais, E. Mead. ***Narbethong, Australia.***—J. T. N. Anderson. ***Newcastle, Australia.***—P. Allan. ***Sydney, Australia.***—W. H. Warren. ***Wellington, New Zealand.***—J. E. Fulton. ***Woollahra, Australia.***—R. Watkins.

ASSOCIATE MEMBERS.—***Adelaide, Australia.***—H. F. Nichols. ***Chelmer, Australia.***—R. D. A. Frew. ***Essendon, Australia.***—W. M. Pullar. ***Fremantle, Australia.***—J. F. Ramsbotham. ***Longford, Tasmania.***—F. P. St. Hill. ***Malloy, Australia.***—A. J. R. Frew. ***Perth, Australia.***—D. G. Heslop. ***Poverty Bay, New Zealand.***—W. S. Charlsworth. ***Sydney, Australia.***—P. Caro. ***Wanganui, New Zealand.***—E. Crow.

ASSOCIATES.—***Sydney, Australia.***—H. L. Hughes.

ADDRESS UNKNOWN.

Total, 10.

MEMBERS.—W. Crawford, E. D. Graves, J. A. Seddon.

ASSOCIATE MEMBERS.—C. A. Engle, T. H. Gronwall, J. G. Johnston, P. A. Schuchart.

JUNIORS.—R. L. Ramsdell, F. M. Terry.

FELLOWS.—G. Merritt.

Total Membership, 6 364.

GEOGRAPHICAL DISTRIBUTION

SUMMARY.

NORTH AMERICA.

CANADA		159
MEXICO		61
UNITED STATES.		
Alabama	38	
Alaska	1	
Arizona	22	
Arkansas	17	
California	389	
Colorado	90	
Connecticut	97	
Delaware	17	
District of Columbia	117	
Florida	41	
Georgia	48	
Hawaii	19	
Idaho	51	
Illinois	307	
Indiana	40	
Iowa	35	
Kansas	35	
Kentucky	55	
Louisiana	40	
Maine	28	
Maryland	78	
Massachusetts	315	
Michigan	99	
Minnesota	65	
Mississippi	27	
Missouri	197	
Montana	45	
Nebraska	26	
Nevada	8	
New Hampshire	11	
New Jersey	196	
New Mexico	17	
New York	1 698	
North Carolina	33	
North Dakota	5	
Ohio	179	
Oklahoma	24	
Oregon	100	
Pennsylvania	509	
Rhode Island	45	
South Carolina	15	
South Dakota	9	
Tennessee	74	
Texas	93	
Utah	31	
Vermont	7	
Virginia	79	
Washington	131	
West Virginia	37	
Carried forward	5 640	220

Brought forward	5 640	220
Wisconsin	44	
Wyoming	15	5 699

CENTRAL AMERICA.

COSTA RICA	4	
GUATEMALA	3	
NICARAGUA	1	
PANAMA	50	58

SOUTH AMERICA.

ARGENTINE REPUBLIC	15	
BOLIVIA	3	
BRAZIL	22	
CHILI	4	
COLOMBIA	5	
ECUADOR	2	
PERU	8	
URUGUAY	1	
VENEZUELA	1	61

WEST INDIA ISLANDS.

CUBA	52	
DOMINICA	1	
HAITI	4	
JAMAICA	3	
PORTO RICO	18	
SANTO DOMINGO	9	
TRINIDAD	1	88

EUROPE.

AUSTRIA	3	
DENMARK	2	
FRANCE	7	
GERMANY	6	
GREAT BRITAIN	48	
ITALY	2	
NETHERLANDS	1	
NORWAY	2	
RUSSIA	7	
SPAIN	1	
SWEDEN	3	
SWITZERLAND	1	83

AFRICA.

Total in Africa		9

ASIA.

CHINA	21	
INDIA	10	
JAPAN	26	
PHILIPPINE ISLANDS	50	
STRAITS SETTLEMENTS	2	109

AUSTRALASIA.

Total in Australasia		27
Address Unknown		10

Total Membership, 6 364.

SUBSCRIBERS TO THE BUILDING FUND.

1881 to 1886.

The names of deceased subscribers to this fund, and of those whose address is unknown, have been omitted from this list, and the names of many living subscribers have, with their consent, also been omitted.

Boston Gas Light Company...... .. ..24 West St., Boston, Mass.

Boyd, Charles R.......................... ....Wytheville, Va.

Griswold, Frank L................Cruz del Eje, Cordoba, Argentine Republic.

Maher & Brayton...Cleveland, Ohio.

Sorzano, Julio F..... ....52 Broadway, New York City.

Towle, Stevenson ....17 West 90th St., New York City.

PAST AND PRESENT OFFICERS

AND YEARS IN WHICH THEY HELD OFFICE.

The figures of the year during which office was held are, to save space, printed without those of the century. In some cases they do not show the year in which office was taken; for instance, an officer whose term extended from November, 1873, to November, 1875, appears in this table as having held office during 1874 and 1875. or 74–75.

The names of deceased members are printed in italics.

NAME.	Pres.	Vice-Pres.	Sec.	Treas.	Director.
ADAMS, ARTHUR LINCOLN					07–09
Adams, Julius Walker	74–75	68–73			53, 76
Allen, Horatio	72–73				
ANDREWS, HORACE					08–10
Archbald, James					87
BATES, ONWARD	09	06–07			
Becker, Max Joseph	89				
BELKNAP, WILLIAM ETHELBERT					10–12
BENSEL, JOHN ANDERSON	10	07–08			99-01
BENZENBERG, GEORGE HENRY	07	01–02			95–97
BISSELL, HEZEKIAH					05–07
BOGART, JOHN			78-90	76-77, 91-94	73–75
BOLLER, ALFRED PANCOAST		11–12	70–71		72
BONTECOU, DANIEL					96–98
Bouscaren, Louis Gustave Frederic		03–04			81
BOWMAN, AUSTIN LORD					05–07
BRACKETT, DEXTER					08–10
BRIGGS, JOSIAH ACKERMAN					01–03
BROWNE, GEORGE HAMILTON					95–97
Brush, Charles Benjamin		92–93			88–91
BUCHHOLZ, CARL WALDEMAR					99–01
Buck, Leffert Lefferts					92–94
BUCK, RICHARD SUTTON					02–04
BURR, WILLIAM HUBERT					94–96
BUSH, LINCOLN					12
CAIN, WILLIAM					12
CARTER, EDWARD CARLOS					01–03
Cartwright, Robert		99–00			95-97
CASEY, THOMAS L.*					82
CATTELL, WILLIAM ASHBURNER					12
Chanute, Octave	91	80–81			74-76, 85
Chesbrough, Ellis Sylvester	78				70
CHESBROUGH, I. C.*					55-67
Christie, James					07–09
CHURCHILL, CHARLES SAMUEL		12			08–10
Clark, Jacob Merrill		72-73			70-71
CLARKE, ELIOT CHANNING					89
CLARKE, GEORGE CALBRAITH					11–12
Clarke, Thomas Curtis	96	71			79
COHEN, MENDES	92	90			88
Collingwood, Francis			91–94		73–76
COOPER, THEODORE					84–85
Copeland, Charles W.		53–69			
CORTHELL, ELMER LAWRENCE		89, 93–94			
COURTENAY, WILLIAM HOWARD					11–12
Craighill, William Price†	94				92–93
CRAVEN, ALFRED					03–05
Craven, Alfred Wingate	70–71	54–67			53, 68–69, 72–73
Croes, John James Robertson	01	88		78–87	77
CROSBY, BENJAMIN LINCOLN					97–99
CROWELL, FOSTER					93–95
CURTIS, FAYETTE SAMUEL		04–05			95–97

* Resigned.

† Elected President during his term of office as Director.

NAME.	Pres.	Vice-Pres.	Sec.	Treas.	Director.
Curtis, William Giddings					90
DAVIS, JOSEPH PHINEAS		84			78, 81–83
DAVISON, GEORGE STEWART					03–05
DEYO, SOLOMON LEFEVRE		04–05			98–00
Dresser, George Warren					82
Eads, James Buchanan		82			
ELLIS, JOHN WALDO					04–06
Ellis, Theodore Grenville		74–77			79
ELY, THEODORE NEWEL					92–93
ENDICOTT, MORDECAI THOMAS	11	08–09			01–03
Fanning, John Thomas¶		10–11			93–95
Fink, Albert	80	78–79			
FISHER, EDWIN AUGUSTUS					05–07
FITZGERALD, DESMOND	99	95–96			92–94
FLAD, EDWARD§					11
Flad, Henry	86	83			
FOOTE, ARTHUR DEWINT					10–12
FORD, JAMES K.*					68–69
FORNEY, MATTHIAS N.*					77
FORSYTH, ROBERT					87
Francis, James Bicheno	81	70, 79–80			
FRAZIER, JAMES LEWIS					02–04
FREEMAN, JOHN RIPLEY		02–03			96–98
Fteley, Alphonse	98	89–91			88
Fuertes, Estevan Antonio					92
Gardiner, Edward		53	54	54	
GARDNER, WILLIAM MONTGOMERY					09–11
GERBER, EMIL					12
GIBBS, GEORGE					06–08
Gillmore, Quincy Adams					76
Gorsuch, Robert Bennett			53	53	
Gottlieb, Abraham					92–93
Gowen, Charles Sewall					04–06
Graff, Frederic	85				84
GRAY, SAMUEL MERRILL		92			
GREEN, BERNARD RICHARDSON		06–07			94–96
Greene, George Sears	76–77				68–69, 71, 73, 75, 77–79
GREENE, GEORGE SEARS, JR.		85		88–90	82–84, 86
Gzowski, Sir Casimir Stanislaus					94
HAINES, HENRY STEVENS		01–02			97–99
HAMILTON, WILLIAM GASTON					83–87
HARRISON, CHARLES LEWIS					08–10
HARROD, BENJAMIN MORGAN	97	95–96			92–94
HAZEN, ALLEN					07–09
HERING, RUDOLPH		00–01			91, 97–99
Hermany, Charles	04	91			80
HERSCHEL, CLEMENS					91
HILL, ALBERT BANKS					92
HODGDON, FRANK WELLINGTON					07–09
Holley, Alexander Lyman		77			76
HOLMAN, MINARD LAFEVER		05–06			
HORTON, HORACE E.					07–09
HUNT, CHARLES WARREN			95–12		
Hutton, William Rich		96–97			84–86
Jackson, William					02–04
JOHNSON, JAMES MORELAND					06–08
Johnson, Lorenzo Medici					97–99
JOHNSON, THOMAS H					00–02
JUST, GEORGE ALEXANDER					96–98
KATTÉ, WALTER					85, 89
KEEFER, THOMAS COLTRIN	88	86–87			82
KENNEDY, JOHN					98–00
KENNEDY, WILLIAM HARLIN†					02–03
KIERSTED, WYNKOOP					06–08
KIMBALL, GEORGE ALBERT					10–12
Kirkwood, James Pugh‡	68				53–67

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* Resigned.

† Elected Director Dec. 3d, 1901, to fill the vacancy caused by the death of George A. Quinlan.

‡ Mr. Kirkwood resigned the Presidency August 5th, 1868, and Mr. McAlpine was elected for the unexpired period.

¶ Mr. Fanning died February 6th, 1911, during his term as Vice-President, and Arthur N. Talbot was elected for the unexpired term.

§ Elected Director Feb. 28th, 1911, to fill the vacancy caused by the election of Mr. Talbot as Vice-President.

PAST AND PRESENT OFFICERS

Name.	Pres.	Vice-Pres.	Sec.	Treas.	Director.
Kittredge, George Watson	....	....	......	......	08–10
Knap, Joseph Moss	....	....	......	00–12	94–96
Kuichling, Emil	....	05–06	......	......	01–03
Landreth, Olin Henry	....	....	......	......	93–95
Landreth, William Barker	....	....	......	......	05–07
Laurie, James	53-67	....	......	......	......
Leverich, Gabriel	....	....	72–77	......	......
Lewis, Eugene Castner	....	....	......	......	03–05, 12
Lewis, Nelson Peter	....	....	......	......	04–06
Loomis, Horace	....	....	......	......	10–12
Loweth, Charles Frederick	....	....	......	......	10–12
Ludlow, William	....	....	......	......	90
Macdonald, Charles	08	93–94	......	......	71, 74-75
MacLeod, John	....	92	......	......	......
McAlpine, William Jarvis†	68–69	....	......	......	54-67, 70
McDonald, Hunter	....	10–11	......	......	03–05
McMath, Robert Emmet	....	....	......	......	89
McNulty, George Washington	....	....	......	......	92–93
McVean, John Jay	....	....	......	......	98–00
Manley, Henry	....	....	......	......	98–00
Martin, Charles Cyril	....	94–95	......	......	......
Marx, Charles David	....	12	......	......	04–06
Mead, Elwood	....	....	......	......	03–05
Mendell, George Henry	....	97–98	......	......	......
Merrill, William Emery	....	....	......	......	83
Metcalf, William	93	....	......	......	83–84
Meyer, Thomas C.‡	....	....	69	......	......
Modjeski, Ralph	....	....	......	......	04–06
Moore, Robert	02	88, 99–00	......	......	92–93
Mordecai, Augustus	....	....	......	......	95–97
Morell, W. H.	....	....	......	......	53
Morison, George Shattuck	95	....	......	......	......
Morris, Henry Gurney	....	....	......	......	86
Morse, Henry Grant	....	....	......	......	97–99
Morse, James Otis	....	....	55–69	55–75	54–67, 77
Myers, Charles Hayward	....	....	......	......	92
Myers, Edmund Trowbridge Dana	....	....	......	......	92
Nichols, Othniel Foster	....	....	......	......	92–93
Noble, Alfred§	03	00–01	......	......	95
North, Edward P.	....	98–99	......	......	91
Ockerson, John Augustus	12	07–08	......	......	......
O'Rourke, John Francis	....	....	......	......	00–02
Osborn, Frank Chittenden	....	....	......	......	01–03
Osgood, Joseph Otis	....	....	......	......	03–05
Owen, James	....	....	......	......	97–99
Paine, Charles	83	....	......	......	......
Paine, William H.	....	82–84	......	......	77–81
Parsons, William Barclay	....	....	......	......	96–98
Pegram, George Herndon	....	09–10	......	......	02–04
Peterson, Peter Alexander	....	96–97	......	......	92–93
Pierson, George Spencer	....	....	......	......	05–07
Pope, Willard Smith	....	....	......	......	93–95
Pratt, J. W.	....	....	......	......	54
Prosser, Thomas	....	....	......	......	70
Prout, Henry Goslee	....	....	......	......	93–95
Quinlan, George Austin	....	....	......	......	00–01
Ramsey, Joseph, Jr.	....	....	......	......	00–02
Read, Robert Leland	....	....	......	......	92–93
Richardson, Henry Brown	....	....	......	......	00–02
Ricketts, Palmer Chamberlaine	....	....	......	......	99–01
Ridgway, Robert	....	....	......	......	11-12
Roberts, Percival, Jr.	....	....	......	......	10-12
Roberts, William Milnor	79	74–76, 78	......	......	77
Rowland, Thomas Fitch	....	86–87	......	......	71–73
Rundlett, Leonard W.	....	....	......	......	11-12
Schneider, Charles Conrad	05	02–03	......	......	87, 98–00
Schuyler, James Dix	....	03–04	......	......	92, 99–01
Seaman, Henry Bowman	....	....	......	......	00–02

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† Mr. Kirkwood resigned the Presidency August 5th, 1868, and Mr. McAlpine was elected for the unexpired term.

‡ November 3d, 1869, to January 5th, 1870.

§ Elected Director Nov. 5th, 1895, to fill the vacancy caused by the death of Willard S. Pope.

Name.	Pres.	Vice-Pres.	Sec.	Treas.	Director.
See, Horace*	....	....	......	......	96-98
Sherrerd, Morris Robeson	....	....	......	......	05-07
Shinn, William Powell	90	....	......	......	89
Sidell, W. H.	....	....	......	......	53
Smith, Charles Shaler	....	....	......	......	78
Smith, Charles Vandervoort	....	....	......	......	78-81
Smith, J. Waldo	....	....	......	......	06-08
Smith, T. Guilford	....	....	......	......	94-96
Snow, Jonathan Parker	....	....	......	......	11-12
Sooysmith, Charles	....	....	......	......	95-97
Staniford, Charles Wilkinson ¶	....	....	......	......	12
Stanton, Robert Brewster	....	....	......	......	94-96
Stearns, Frederic Pike	06	98-99	......	......	93-95
Storey, William B., Jr.	....	....	......	......	06-08
Stott, Henry Gordon.*	....	....	......	......	11
Strobel, Charles Louis†	....	11-12	......	......	86. 94
Stuart, Francis Lee	....	....	......	......	09-11
Sumner, Horace Augustus	....	....	......	......	09-11
Swain, George Fillmore	....	08-09	......	......	01 03
Swensson, Emil	....	09-10	......	......	06-08
Symons, Thomas William*	....	....	......	......	96-98
Talbot, Arthur Newell.§	....	11	......	......	09-10
Talcott, William Hubbard	....	....	......	......	54-68
Thompson, Samuel Clarence	....	....	......	......	09-11
Thomson, John	....	....	......	95-99	92-94
Thomson, T. Kennard	....	....	......	......	12
Tillson, George William	....	....	......	......	07-09
Towle, Stevenson	....	....	......	......	87-88
Turner, Edmund Kimball	....	....	......	......	99-01
Van Buren, Robert	....	....	......	......	90
Van Hoesen, Edmund French	....	....	......	......	02-04
Van Horne, John Garret	....	....	......	......	92
Van Winkle, Edgar Beach	....	....	......	......	80
Vaughan, Frederic Willis	....	....	......	......	85
Voorhees, Theodore	....	....	......	......	90
Wallace, John Findley	00	97-98	......	......	......
Ward, John Frothingham*	....	....	......	......	68-72
Warren, Gouverneur K.*	....	....	......	......	80
Webster, George Smedley	....	....	......	......	04-06
Welch, Ashbel‡	82	81	......	......	......
Whinery, Samuel	....	92-93	......	......	91, 99-01
Whitcomb, Henry Donald	....	....	......	......	94-96
White, William Howard	....	....	......	......	86
Whitman, Thomas Jefferson	....	85	......	......	......
Whittemore, Don Juan	84	....	......	......	81
Wilgus, William John	....	....	......	......	02-04
Wilkins, William Glyde	....	....	......	......	09-11
Williams, Gardner Stewart	....	....	......	......	08-10
Wilson, Joseph Miller	....	94-95	......	......	88
Wisner, George Y.	....	....	......	......	98-00
Wood, De Volson*	....	....	......	......	74
Worthen, William Ezra	87	....	......	......	72

* Resigned.

† Elected Director to fill the vacancy caused by the death of Abraham Gottlieb, Feb. 9th, 1894.

‡ Mr. Welch died September 25th, 1882, during his term of office as President.

¶ Elected Director Jan. 2d, 1912, to fill the vacancy caused by the resignation of Mr. Stott.

§ Elected Vice-President Feb. 28th, 1911, to fill the vacancy caused by the death of John T. Fanning.

DECEASED

H. M., Honorary Member. M., Member. A., Associate. A. M., Associate Member. J., Junior. F., Fellow.

Name	Date of Election	Date of Death	Memoirs[*]
Abbott, Arthur Vaughan	J. 1881 M. Dec. 4, 1901	Dec. 1, 1906	....
Abbott, Job	M. April 1, 1891	Aug. 18, 1896	*XXXVI, 538*
Abert, John James	H. M. Mar. 2, 1853	Jan. 27, 1862	XIX, 88
Abert, Sylvanus Thayer	M. Sept. 21, 1870	Aug. 11, 1903	*LIX, 521*
Ackenheil, Charles	M. Feb. 2, 1887	June 20, 1890	XVII, 137
Adams, Julius Walker	M. 1852 H. M. Oct. 26, 1888	Dec. 13, 1899	....
Adgate, George	M. April 1, 1896	Jan. 23, 1909	*LXV, 514*
Ainslie, George	F. May 28, 1872	Sept. 6, 1878	XV, 41
Ainslie, James W	F. May 28, 1872	Sept. 13, 1902	....
Ainsworth, Danforth Hurlbut	M. Mar. 3, 1886	April 24, 1904	*LIV, 522*
Aldrich, James Colwell	M. May 7, 1873	April 3, 1900	*XLV, 617*
Allaire, William Miller	J. Mar. 2, 1881	Dec. 14, 1884	XIX, 67
Allen, Horatio	M. 1867 H. M. Mar. 4, 1874	Dec. 31, 1889	XVI, 180
Allen, Theodore	M. Nov. 16, 1870	Sept. 18, 1890	XVII, 240
Allen, William Albert	M. May 6, 1891	Mar. 21, 1896	*XXXVI, 539*
Allis, Edward Phelps	F. Aug. 4, 1883	April 1, 1889	XV, 168
Ambrose, William Creelman	M. April 4, 1888	Jan. 3, 1909	....
Anderson, Adna	M. Sept. 2, 1874	May 15, 1889	XV, 166
Ansley, George Doane	M. Sept. 4, 1878	Sept. 22, 1883	XV, 109
Archbald, James	M. May 15, 1872	Oct. 5, 1910	*LXXII, 586*
Armington, James Hervey	M. July 6, 1870	Oct. 14, 1906	....
Arthur, William Young	M. 1867 F. Sept. 20, 1870	Feb. 15, 1876	....
Aspinwall, William Howard	F. July 9, 1870	Jan. 18, 1875	*XXXVI, 598*
Asserson, Peter Christian	M. July 5, 1882	Dec. 6, 1906	....
Atkinson, John Bond	M. Sept. 5, 1877	Sept. 21, 1911	*LXXIV, 492*
Atwood, William Henry	M. May 4, 1881	Sept. 4, 1890	XVII, 205
Avery, John	M. Dec. 4, 1867	Jan. 30, 1884	XI, 117
Bache, Alexander Dallas	H. M. Mar. 2, 1853	Feb. 17, 1867	*XXXVI, 522*
Bacon, John Watson	M. July 12, 1877	Feb. 27, 1907	....
Baier, Julius	J. 1887 A. M. 1892 M. Feb. 6, 1901	May 8, 1905	....
Bailey, George Irving	M. Oct. 1, 1890	Mar. 28, 1908	*LXI, 556*
Bailey, Thomas Norton	M. Nov. 7, 1883	April 20, 1886	XVI, 186
Baker, *Sir* Benjamin	H. M. May 5, 1897	May 19, 1907	....
Baker, William Latimer	J. 1875 M. Nov. 6, 1878	May 28, 1888	XV, 111
Baldwin, Henry Furlong	A. M. 1892 M. Feb. 6, 1895	June 17, 1909	*LXVII, 621*
Ball, Ernest Stearns	J. May 2, 1905	Nov. 22, 1909	*LXVI, 510*
Bannister, Charles Kimball	M. May 3, 1893	Jan. 10, 1901	....
Barber, Amzi Lorenzo	F. Mar. 19, 1886	April 18, 1909	....
Barbour, William Sullivan	M. April 17, 1872	Feb. 24, 1889	XV, 142
Barnard, John Fiske	M. Sept. 1, 1880	Feb. 6, 1910	*LXVIII, 469*
Barnard, John Gross	M. 1869 H. M. April 7, 1873	May 14, 1882	XIII, 134
Barnes, David Leonard	M. July 2, 1890	Dec. 15, 1896	*XLI, 618*
Barnes, James	M. Mar. 13, 1853	Feb. 12, 1869	*XXXVI, 540*
Barnes, Oliver Weldon	M. July 6, 1881	Nov. 14, 1908	....
Barnsley, George Thomas	J. 1892 A. M. 1894 M. Feb. 6, 1906	Oct. 23, 1909	....
Barr, Jacob Neff	M. Nov. 7, 1888	May 15, 1904	....
Barriger, John Walker, Jr	J. 1898 A. M. April 2, 1902	Dec. 19, 1902	*LVI, 477*
Bartlett, Winthrop	M. Jan. 2, 1889	Jan. 16, 1899	....
Bassell, Burr	M. Nov. 4, 1903	Feb. 25, 1905	....
Batterson, James Goodwin	F. June 7, 1876	Sept. 18, 1901	....
Baumann, Edward	A. June 2, 1880	Jan. 26, 1889	XV, 114
Bayley, George William Read	M. July 10, 1872	Dec. 14, 1876	IV, 58
Beardsley, Frank Chester	M. Nov. 7, 1894	July 1, 1895	XXI, 182
Becker, Max Joseph	M. Aug. 7, 1872	Aug. 23, 1896	*XXXVII, 555*

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[*] The italic references in this list are to the volume and page of *Transactions*, in which the Memoirs prepared after January 1st, 1896, were published; the other figures refer to the volume and page of *Proceedings*, where the Memoirs prepared earlier than that date will be found.

Name		Date of Election	Date of Death	Memoirs*
Beckler, Elbridge Harlow	M.	April 6, 1892	Aug. 26, 1908	....
Behrens, William Frederic	J.	1889 A. M. June 7, 1893	Feb. 6, 1894	XX, 87
Belknap, Morris Sheppard	M.	Aug. 7, 1872	July 19, 1890	XVI, 167
Bell, George Joseph	A. M.	1898 M. Oct. 1, 1902	Oct. 6, 1911	*LXXIV, 495*
Bell, Henry Purdon	M.	June 4, 1884	Oct. 19, 1910	*LXXIV, 496*
Bell, James E	M.	Mar. 5, 1879	June 9, 1879	V, 98
Bennett, Frederick Wagoner	M.	Oct. 7, 1903	Jan. 8, 1912	....
Bentley, Henry Adamson	M.	Mar. 2, 1881	May 13, 1889	....
Benyaurd, William H. H	M.	Nov. 3, 1875	Feb. 7, 1900	....
Beresford, Frank	J.	Sept. 7, 1887	Dec. 12, 1887	*XXXVI, 594*
Berg, Walter Gilman	M.	Feb. 5, 1896	May 12, 1908	....
Bergengren, Fritz Carl Anders Georg	A. M.	Dec. 2, 1896	Aug. 8, 1904	....
Berrian, Richard Milford	M.	May 4, 1887	Dec. 23, 1907	*LXII, 550*
Biddle, William Foster	M.	June 4, 1884	Aug. 10, 1910	*LXXI, 401*
Birch-Nord, Carl William	J.	1906 A. M. Nov. 4, 1908	Sept. 15, 1909	*LXVI, 509*
Birks, Arthur Henry	J.	1904 A. M. Nov. 7, 1906	Aug. 29, 1907	....
Bishop, George H	M.	Aug. 7, 1872	Aug. 20, 1909	....
Bishop, Thomas Sparks	M.	Sept. 2, 1885	Nov. 13, 1898	*XLI, 621*
Blackwell, Charles	M.	Sept. 7, 1881	Dec. 29, 1906	*LIX, 531*
Blaisdell, Anthony Houghtaling	M.	Mar. 3, 1880	Sept. 9, 1905	*LVI, 464*
Blake, Edward Josiah	M.	April 3, 1889	May 29, 1902	....
Blickensderfer, Jacob	M.	June 1, 1881	Feb. 26, 1899	....
Bliss, Henry Isaac	M.	Sept. 5, 1883	July 10, 1896	*XXXVI, 541*
Blunden, Henry D	J.	1876 M. Feb. 4, 1880	Jan. 7, 1889	*XXXVI, 542*
Bodfish, Sumner Homer	M.	Oct. 2, 1889	May 17, 1894	XX, 96
Boeke, August William	M.	Sept. 3, 1890	Oct. 24, 1894	XX, 204
Bogart, James Peter	J.	1882 M. July 3, 1895	Dec. 24, 1903	*LII, 545*
Bond, Frederick Winn	M.	Dec. 7, 1898	July 12, 1903	*LI, 452*
Booker, Bernard Frank	J.	1885 M. June 2, 1891	July 21, 1894	XX, 183
Both, Carl Christian Adolph	M.	Sept 2, 1891	Jan. 12, 1906	....
Bouscaren, Louis Gustave Frederic	M.	April 7, 1875	Nov. 6, 1904	*LIX, 533*
Bouton, Nathaniel S	F.	Dec. 30, 1872	April 3, 1908	....
Bowman, Joseph Hockman	A. M.	Dec. 2, 1903	†	....
Boyle, Olin McClintock, Jr	J.	Mar. 5, 1907	Aug. 19, 1908	*LXIV, 591*
Bradbury, Henry Robert	A.	July 6, 1881	July 3, 1901	....
Breckinridge, Cabell	M.	June 1, 1881	Nov. 13, 1907	*LXV, 529*
Breen, Howard	M.	April 4, 1888	Feb. 14, 1909	....
Bridgford, John	F.	Jan. 14, 1871	Mar. 8, 1898	....
Briggs, Albert Dwight	F.	May 17, 1870	Feb. 20, 1881	XV, 132
Briggs, Robert	M.	Oct. 19, 1870	July 24, 1882	*XXXVI, 542*
Briggs, Roswell Emmons	M.	Sept. 15, 1869	May 4, 1911	....
Brinckerhoff, Henry Waller	M.	Nov. 7, 1883	Sept. 7, 1909	*LXVI, 495*
Brodhead, Calvin Easton	M.	Feb. 21, 1872	April 29, 1907	*LX, 579*
Brough, Redmond John	M.	Sept. 1, 1880	July 21, 1883	XII, 40
Brown, Alba Fisk	M.	Sept. 7, 1887	April 22, 1906	....
Brown, Charles Irwin	M.	Jan. 7, 1891	Mar. 23, 1899	....
Brown, John Milton	M.	April 1, 1874	June 16, 1874	I, 170
Brown, Linus Weed	M.	June 7, 1899	Mar. 7, 1910	*LXX, 470*
Browne, William Robert	M.	June 1, 1898	Sept. 3, 1908	....
Bruner, Daniel Pastorius	J.	1876 M. May 7, 1879	Aug. 29, 1901	....
Brush, Charles Benjamin	A.	1871 M. Sept. 5, 1877	June 3, 1897	....
Brynn, Per	A. M.	Feb. 4, 1903	Feb. 10, 1906	*LVII, 528*
Buck, Leffert Lefferts	M.	Feb. 3, 1875	July 17, 1909	*LXXIII, 493*
Buckhout, Isaac Craig	M.	July 15, 1872	Sept. 27, 1874	I, 171
Burden, Henry	H. M.	Mar. 2, 1853	Jan. 19, 1871	....
Burden, James Abercrombie	M.	July 2, 1879	Sept. 23, 1906	....
Burns, Justin	A. M.	April 6, 1898	Nov. 14, 1905	*LVII, 529*
Burns, Robert Bruce	M.	Sept. 5, 1900	June 21, 1906	....
Burr, James Dewey	M.	April 5, 1876	May 5, 1886	XII, 107
Burrowes, Francis Smith	M.	June 6, 1888	Feb. 15, 1909	....
Burton, Standish Barry	M.	June 1, 1898	Aug. 13, 1904	*LV, 444*
Butts, Elijah Polhill	J.	Nov. 3, 1886	Jan. 11, 1892	XVIII, 129
Buxton, Clifford	M.	May 6, 1885	Jan. 12, 1910	*LXVII, 623*
Caldwell, George Bowers	M.	April 1, 1908	Mar. 31, 1911	*LXXIII, 498*
Camp, Jonathan, Jr	M.	Dec. 31, 1873	April 16, 1874	I, 186
Campbell, Albert Johnstone	A. M.	May 2, 1894	Mar. 23, 1907	*LIX, 563*
Campbell, Allan	M.	1868 H. M. Mar. 1, 1892	Mar. 18, 1894	XX, 179
Campbell, Charles Edward Henry	M.	Oct. 3, 1883	Dec. 6, 1902	*LII, 547*
Card, Joseph P	A.	Sept. 5, 1883	Oct. 22, 1894	XXI, 68
Card, William Warren	M.	Sept. 5, 1883	April 4, 1903	....
Carothers, Daniel Dawson	M.	April 4. 1894	Jan. 2, 1909	*LXIV, 581*

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† Date of death unknown.

DECEASED C-D

Name		Date of Election	Date of Death	Memoirs*
Carpenter, Clarence Allan	M.	May 2, 1888	Nov. 9, 1899	*LXXI, 403*
Carrel, Frederick Janvrin	M.	Mar. 5, 1884	May 2, 1894	*XXXVII, 559*
Cartwright, Henry	M.	Sept. 6, 1876	June 30, 1881	VII, 124
Cartwright, Robert	M.	July 10, 1872	June 4, 1905	....
Cary, Edgar Sheldon	M.	Nov. 1, 1882	Jan. 5, 1883	*XLVI, 555*
Cass, George Washington, Jr	F.	Mar. 30, 1871	Mar. 21, 1888	*XXXVI, 599*
Catt, George William	M.	Sept. 7, 1892	Oct. 8, 1905	....
Chanute, Octave	M.	1868 F. July 11, 1872	Nov. 23, 1910	*LXXIV, 483*
Chase, Samuel Stewart	M.	1868 F. Mar. 12, 1870	May 29, 1873	I, 40
Chase, William Beverly	M.	Sept. 6, 1899	Oct. 27, 1908	*LXIII, 429*
Cheney, John Eugene	M.	May 7, 1884	Sept. 25, 1906	*LIX, 537*
Cheney, Nathaniel	F.	June 21, 1870	June 29, 1901	....
Chesbrough, Ellis Sylvester	M.	June 17, 1868	Aug. 18, 1886	XV, 160
Christie, James	M.	May 7, 1873	Aug. 24, 1911	....
Church, George Earl	M.	Nov. 2, 1887	Jan. 5, 1910	*LXXI, 405*
Cisneros, Francisco Javier	M.	May 15, 1872	July 7, 1898	*XLI, 622*
Clapp, Lorenzo Russell	M.	Feb. 1, 1888	Aug. 13, 1902	*XLIX, 341*
Clapp, William Billings	M.	Dec. 6, 1905	Dec. 26, 1911	....
Clark, Ira Edgar	J.	Feb. 6, 1878	May 23, 1882	VIII, 92
Clark, Jacob Merrill	M.	Jan. 29, 1868	Dec. 21, 1894	XX, 203
Clark, John Howard	M.	Nov. 4, 1903	Oct. 13, 1907	....
Clarke, Henry Wadsworth	M.	Mar. 15, 1871	Feb. 23, 1892	XVIII, 93
Clarke, Thomas Curtis	M.	1868 F. May 20, 1872	June 15, 1901	*L, 495*
Cleemann, Thomas Mutter	M.	Oct. 1, 1879	Nov. 16, 1893	XX, 69
Clemens, Ernest Victor	M.	Mar. 1, 1893	Sept. 3, 1893	XX, 161
Clement, Victor M	F.	Jan. 8, 1890	April 28, 1903	....
Cleverdon, Henry Lawrence	A. M.	Mar. 1, 1899	Aug. 27, 1902	*L, 507*
Cobb, Robert Linah	M.	Jan. 2, 1890	June 2, 1895	*XXXVI, 545*
Cochran, A. P	F.	June 19, 1872	April 26, 1886	....
Coffin, Freeman Clarke	M.	Feb. 6, 1895	Nov. 11, 1906	*LVIII, 532*
Colburn, Warren	M.	Mar. 18, 1868	Sept. 15, 1879	VI, 4
Colburn, Zerah	M.	Jan. 5, 1855	April 26, 1870	*XXXVI, 546*
Colby, Charles Lewis	F.	July 31, 1883	Feb. 26, 1896	....
Coleman, Thomas Cooper	F.	May 28, 1872	Dec. 17, 1901	....
Collingwood, Francis	M.	Mar. 3, 1869	Aug. 18, 1911	....
Colman, Isaac D	M.	Feb. 27, 1869	April 7, 1875	I, 331
Comfort, Silas Gildersleeve	A.	Mar. 31, 1891	July 13, 1910	*LXXI, 452*
Connor, Addison	M.	Jan. 5, 1887	Jan. 4, 1891	*XXXVI, 551*
Conro, Albert	F.	June 13, 1883	Jan. 10, 1901	....
Constable, Casimir	M.	June 17, 1868	Feb. 6, 1905	....
Cooke, Robert Latimer	M.	April 17, 1872	Aug. 11, 1877	IV, 66
Cooper, Edward	F.	Dec. 10, 1885	Feb. 25, 1905	....
Coppée, Henry St. Leger	M.	Oct. 5, 1887	May 8, 1901	....
Correa, Edward Arnold	M.	Mar. 7, 1900	June 24, 1900	*XLV, 621*
Coryell, Martin	M.	Dec. 4, 1867	Nov. 30, 1886	XV, 133
Courtwright, Milton	F.	June 11, 1870	April 25, 1883	....
Covode, James Henry	M.	April 2, 1890	Sept. 9, 1909	*LXXII, 589*
Cox, Abraham Beekman	M.	April 1, 1874	Feb. ‡ 1906	....
Coxe, Eckley Brinton	M.	Feb. 7, 1877	May 13, 1895	*XXXVI, 552*
Crabb, Thomas	J.	April 4, 1899	Dec. 21, 1901	....
Craighill, William Price	M.	1885 H. M. Mar. 23, 1896	Jan. 18, 1909	*LXV, 517*
Craven, Alfred Wingate	M.	Nov. 5, 1852	Mar. 27, 1879	VI, 24
Craven, Henry Smith	M.	Dec. 3, 1884	Dec. 7, 1889	XVI, 217
Croes, John James Robertson	M.	Dec. 4, 1867	Mar. 17, 1906	*LVIII, 524*
Crosby, Wilson	M.	Sept. 15, 1869	Dec. 18, 1904	*LXVII, 625*
Cunningham, John Miller	A. M.	Oct. 7, 1903	Aug. 8, 1904	*LIV, 537*
Cunningham, Paul Davis	A. M.	Mar. 1, 1899	July 13, 1901	*LII, 556*
Curtis, Wendell Rhodes	J.	1875 M. June 4, 1884	Mar. 7, 1893	XX, 86
Curtis, William Giddings	M.	May 3, 1882	June 15, 1900	*XLV, 624*
Cushing, Oliver Edwards	M.	July 10, 1872	Jan. 17, 1890	XVI, 166
Cushing, Robert Delano	A. M.	Sept. 6, 1899	Aug. 23, 1903	....
Cushing, Samuel Barrett	M.	Sept. 2, 1869	July 17, 1873	I, 43
Cushing, Samuel Barrett	M.	June 1, 1887	Dec. 2, 1888	*XLIX, 343*
Cutshaw, Wilfred Emory	M.	Mar. 4, 1891	Dec. 19, 1907	*LXXI, 408*
Dagron, James Gustavus	M.	Oct. 6, 1886	May 25, 1895	....
Davidson, George	H. M.	May 5, 1897	Dec. 2, 1911	....
Davidson, Matthias Oliver	M.	April 6, 1853	Sept. 1, 1872	XIX, 56
Davis, Charles	M.	Sept. 15, 1869	Feb. 20, 1907	*LXXI, 411*
Davis, Frank Leslie	M.	Sept. 6, 1905	June 9, 1909	*LXXIII, 500*
Davis, Frank Paul	M.	Feb. 1, 1888	May 3, 1900	....
Davis, John Woodbridge	A.	June 3, 1885	Nov. 7, 1902	*XLIX, 370*
Dawley, Edwin Peleg	M.	April 1, 1885	Oct. 7, 1910	*LXXI, 413*
Deans, Charles Herbert	J.	1890 A. M. May 6, 1896	Mar. 7, 1909	*LXVIII, 482*

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‡ Exact date of death unknown.

Name	Date of Election	Date of Death	Memoirs*
Dearborn, William Lee	M. Jan. 29, 1868	Mar. 15, 1875	I, 330
DeCourcy, Bolton Waller	M. Nov. 6, 1889	April 1, 1900	....
DeForest, George Thompson	A. M. Dec. 4, 1895	July 25, 1901	....
de Funiak, Frederick	M. May 7, 1873	Mar. 29, 1905	*LIV, 524*
DeGaray, Francisco	F. Aug. 31, 1883	Sept. 2, 1896	....
DeHaas, Adolph	J. Oct. 3, 1905	Dec. 28, 1907	....
Del Monte, Emilio	M. Dec. 4, 1895	Mar. 20, 1902	....
Derbishire, James Stewart	M. April 2, 1884	Jan. 2, 1887	XIII, 66
Dexter, George M.	M. Dec. 3, 1852	Nov. 26, 1872	I, 40
Dickinson, George Codwise	M. Feb. 5, 1890	Jan. 24, 1892	XVIII, 71
Dickinson, Pomeroy P.	M. Jan. 17, 1872	Oct. 4, 1895	*XLIII, 611*
Dillon, Sidney	F. Mar. 26, 1870	June 9, 1892	*XXXVI, 603*
Dimmick, John Bagley	M. July 10, 1907	June ‡, 1909	....
d'Invilliers, Camille Stanislaus	M. Jan. 4, 1888	Jan. 2, 1910	....
Dirks, Justus	H. M. June 2, 1880	Dec. 26, 1886	XIII, 45
Diven, Alexander Samuel	F. June 16, 1870	June 11, 1896	*XXXVII, 571*
Doane, Thomas	M. June 7, 1882	Oct. 22, 1897	*XXXIX, 690*
Doran, Frank C.	M. Sept. 5, 1883	Oct. 15, 1898	....
Dorsey, Edward Bates	M. June 4, 1879	†	....
Douglas, Benjamin	J. 1887 M. Jan. 2, 1890	Nov. 13, 1911	....
Downes, Stancliff Bazen	J. April 7, 1886	April 21, 1895	XXI, 105
Dresser, George Warren	M. July 5, 1876	May 27, 1883	XIX, 110
Duane, James	M. Mar. 2, 1892	Jan. 12, 1899	....
Duane, James Chatham	H. M. Nov. 20, 1886	Nov. 8, 1897	*XXXIX, 686*
DuBarry, Edmund Louis	A. Jan. 6, 1875	Dec. 4, 1908	....
Du Barry, Joseph Napoleon	M. Jan. 6, 1875	Dec. 17, 1892	XIX, 108
Dudley, Charles Benjamin	M. Mar. 2, 1892	Dec. 21, 1909	....
Dudley, Charles Tarbell	J. 1904 A. M. Oct. 3, 1906	Sept. 30, 1908	*LXIV, 588*
Dun, James	M. June 7, 1876	Feb. 23, 1908	*LXI, 560*
Dunham, Charles Frederick	M. April 2, 1902	June 13, 1903	....
Durant, Thomas C.	F. Nov. 18, 1870	Oct. 5, 1885	*XXXVI, 602*
Dusenberry, Walter Lorton	J. Nov. 5, 1890	May 13, 1909	*LXV, 533*
Eads, James Buchanan	M. 1868 F. Mar. 30, 1870	Mar. 8, 1887	XIII, 46
Earley, John Edwin	M. April 5, 1876	Dec. 20, 1907	*LXI, 562*
Eaton, Horace LaFayette	M. Feb. 1, 1893	Nov. 23, 1895	*XXXVI, 554*
Eayrs, Norman Wilder	M. June 3, 1885	May 13, 1900	....
Edge, George Washington	M. Mar. 4, 1874	Jan. 1, 1880	VI, 18
Edwards, Nathaniel Marsh	M. June 3, 1874	†	....
Eldridge, Archibald Ronaldson	M. Oct. 2, 1901	Jan. 17, 1907	....
Elliott, George Harford	M. April 4, 1883	Oct. 7, 1886	XV, 110
Ellis, Nathaniel Webster	M. Feb. 2, 1881	Jan. 16, 1889	XV, 112
Ellis, Samuel Clarence	M. Aug. 7, 1872	Jan. 21, 1912	....
Ellis, Theodore Grenville	M. 1869 F. Nov. 21, 1872	Jan. 9, 1883	*XXXVII, 557*
Ellsworth, Alfred Burnham	J. May 1, 1889	Jan. 10, 1893	XIX, 48
Ely, George Hervey	A. May 31, 1892	Jan. 24, 1894	....
Emack, Charles S.	M. July 6, 1870	July 26, 1877	IV, 65
Emerson, George Dana	M. Sept. 18, 1872	Sept. 26, 1900	....
Emery, Charles Edward	M. May 6, 1874	June 1, 1898	*XLII, 558*
Emigh, John Hall	M. April 3, 1901	Jan. 6, 1910	*LXVII, 628*
Emmet, Thomas Addis	M. Nov. 5, 1852	Jan. 12, 1880	VI, 2
Emmons, Charles Morton	M. April 1, 1903	Sept. 14, 1911	*LXXIV, 499*
Emonts, William Alexis George	J. Sept. 6, 1876	Nov. 5, 1887	*XXXVI, 594*
Engle, Robert L.	M. Sept. 7, 1881	Oct. 17, 1909	*LXVIII, 480*
Enos, George Wallace	J. Mar. 6, 1900	Nov. 2, 1905	....
Ensign, Elisha Williams	F. May 18, 1870	Oct. 1, 1877	....
Erdmann, Earl Edwin	J. July 1, 1909	Mar. 28, 1910	*LXXIV, 529*
Ericsson, John	H. M. Oct. 2, 1879	Mar. 8, 1889	....
Evans, Anthony Walton White	M. 1867 F. Mar. 15, 1870	Nov. 28, 1886	XIII, 30
Evans, George Edwin	M. May 2, 1888	April 14, 1908	....
Evans, Louis Provost	M. Sept. 3, 1884	Aug. 19, 1896	....
Evans, Myron Edward	J. 1895 A. M. Feb. 7, 1900	Feb. 16, 1907	....
Ewing, William Bion	J. 1889 A. M. 1892 M. Nov. 2, 1898	April 8, 1911	*LXXIV, 500*
Falconnet, Eugene F.	M. June 3, 1874	Oct. 14, 1887	XV, 135
Fales, Frank Lewis	A. M. April 6, 1904	Oct. 5, 1905	....
Fanning, John Thomas	M. Aug. 7, 1872	Feb. 6, 1911	....
Fargo, William G.	F. May 6, 1870	Aug. 4, 1881	....
Farnam, Henry	F. Nov. 14, 1872	Oct. 4, 1883	*XXXVI, 605*
Farnham, Irving Tupper	M. May 1, 1907	Sept. 19, 1908	*LXXI, 415*
Farquhar, Francis Ulric	M. July 10, 1872	July 3, 1883	XV, 165
Farren, B. N.	F. Mar. 12, 1870	Jan. 21, 1912	....
Fava, Francis Renatus, Jr.	M. Nov. 5, 1890	Mar. 27, 1896	....

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† Date of death unknown.

‡ Exact date of death unknown.

DECEASED F-G

Name	Date of Election	Date of Death	Memoirs*
Feind, Anthony Erneste Bernhard	M. Jan. 2, 1890	Aug. 21, 1894	XX,182
Felton, Samuel Morse	F. Mar. 23, 1870	Jan. 24, 1889	XIX, 92
Ferrier, Joseph James	J. Dec. 3, 1907	Oct. 30, 1911	*LXXIV, 530*
Field, Burr Kellogg	M. Oct. 1, 1884	Jan. 13, 1898	*XL, 568*
Filley, Hiel Hamilton	M. Jan. 3, 1883	May 6, 1907	....
Fink, Albert	M. 1870 F. Sept. 3, 1872	April 3, 1897	*XLI, 626*
Fisher, Charles Henry	M. June 7, 1869	Jan. 18, 1888	XIX, 66
Fisher, Clark	M. Oct. 19, 1870	Dec. 31, 1903	....
Fisher, Elstner	J. 1889 A. M. 1897 M. Mar. 5, 1902	Oct. 12, 1909	*LXVI, 497*
Flad, Henry	M. Feb. 15, 1871	June 20, 1898	*XLII, 561*
Flint, Edward Austin	M. May 18, 1870	Jan. 23, 1886	XII, 114
Flynn, Benjamin Harrison	J. Oct. 2, 1900	Mar. 1, 1903	....
Flynn, Patrick John	M. Feb. 4, 1891	June 1, 1893	XX, 68
Fogg, Charles E.	M. Oct. 16 1872	April 26, 1891	XVII, 230
Ford, Arthur Livermore	A. Nov. 6, 1872	May 30, 1880	VI, 75
Forshey, Caleb Goldsmith	M. Aug. 7, 1872	July 25, 1881	*XXXVII, 560*
Fowler, Charles Edward	M. May 3, 1876	Jan. 28, 1883	XV, 164
Francis, James	M. Jan. 4, 1893	Dec. 1, 1898	*XLV, 627*
Francis, James Bicheno	M. 1852 F. 1870 H. M. April 5, 1892.	Sept. 18, 1892	XIX, 74
Frank, George William	M. Feb. 1, 1899	Jan. 19, 1905	....
Franklin, William Buel	M. April 1, 1874	Mar. 8, 1903	....
Frazer, Joseph Heckart	J. Mar. 31, 1908	Aug. 16, 1911	....
Freeman, Ernest Grey	A. M. 1893 M. Oct. 5, 1898	Mar. 6, 1900	....
Freeman, Frank Leslie	A. Nov. 5, 1895	Mar. 3, 1907	....
French, Edmund	M. Nov. 26, 1852	July 7, 1860	*XXXVII, 561*
French, Frederick Reginald	M. Sept. 7, 1904	Nov. 20, 1904	*LIV, 526*
French, George Harrison	A. M. Dec. 5, 1906	July 9, 1909	....
Frizell, Joseph Palmer	M. Jan. 3, 1883	May 4, 1910	*LXXIII, 501*
Frost, Benjamin Dix	M. Feb. 21, 1872	July 19, 1880	XIII, 139
Fry, Leslie Monroe	J. 1905 A. M. April 3, 1907	Nov. 10, 1908	....
Fteley, Alphonse	M. Jan. 5, 1876	June 11, 1903	*LIV, 509*
Fuertes, Estevan Antonio	M. Feb. 17, 1869	Jan. 16, 1903	....
Fujino, Shukichi	J. Feb. 3, 1903	†	....
Gardiner, Edward	M. Nov. 5, 1852	†	....
Gardner, George Clinton	M. Nov. 3, 1875	Aug. 12, 1904	....
Gardner, Henry A.	M. Dec. 13, 1852	July 26, 1875	I, 335
Garfias, Ignacio	M. Oct. 5, 1892	Jan. 16, 1898	....
Gatchell, George Samuel	M. May 7, 1884	June 22, 1909	....
Gelette, William Durfree	M. April 1, 1885	April 27, 1902	*L, 500*
Gibbs, Nathan Jackson	A. M. May 2, 1911	Dec. 27, 1911	....
Giblin, Arthur Leon	J. Jan. 31, 1893	July 17, 1894	XX, 171
Gibson, William, Jr.	A. Sept. 5, 1888	April 19, 1905	....
Gillespie, Joshua Lathrop	J. 1875 M. April 2, 1884	Aug. 22, 1890	XVI, 224
Gillham, Robert	M. June 2, 1886	May 19, 1899	*XLIII, 613*
Gilliss, John Roberts	M. 1869 F. Mar. 15, 1870	July 15, 1870	*XXXVI, 555*
Gillmore, Quincy Adams	M. Dec. 2, 1868	April 7, 1888	XX, 60
Gilman, Charles Carroll	F. May 11, 1871	July 31, 1899	....
Goad, Charles Edward	M. Sept. 7, 1881	June 10, 1910	*LXXI, 418*
Golay, Philip	M. Sept. 5, 1877	Oct. 31, 1898	....
Goodwin, Homer Stanley	M. July 20, 1870	Dec. 25, 1892	XIX, 163
Goodwin, John Marston	M. Sept. 4, 1872	Oct. 21, 1891	XVII, 267
Gorringe, Henry H.	A. April 6, 1881	July 6, 1885	XVI, 215
Gorsuch, Robert Bennett	H. M. Jan. 9, 1905	June 2, 1906	....
Gottlieb, Abraham	M. Sept. 4, 1872	Feb. 9, 1894	XX, 76
Gould, Edward Sherman	M. Nov. 4, 1885	Jan. 24, 1905	*LIV, 528*
Gowen, Charles Sewall	M. Mar. 7, 1888	Oct. 19, 1909	....
Graff, Frederic	M. May 7, 1873	Mar. 30, 1890	XVII, 247
Graham, Joseph Marshall	M. April 4, 1900	Feb. 3, 1909	*LXIV, 583*
Grain, William	M. Sept. 15, 1869	Jan. 10, 1877	....
Grant, William Harrison	M. July 2, 1873	Oct. 12, 1896	*XXXVI, 557*
Grassau, H.	M. July 6, 1853	May 16, 1870	....
Green, Rutger Bleecker	J. 1896 A. M. 1898 M. Sept. 6, 1904	Dec. 8, 1908	*LXIV, 585*
Greene, Benjamin Henry	M. May 1, 1878	Jan. 4, 1890	XVI, 187
Greene, Charles Ezra	M. Jan. 4, 1882	Oct. 17, 1903	....
Greene, David Maxson	M. May 20, 1868	Nov. 9, 1905	*LVI, 466*
Greene, Edward Appleton	M. July 4, 1888	April 19, 1903	....
Greene, George Sears	M. 1852 H. M. Oct. 26, 1888	Jan. 28, 1899	*XLIX, 335*
Greene, Joseph Norton	M. Oct. 5, 1887	July 26, 1904	*LV, 446*
Greenwood, William Henry	M. Mar. 3, 1880	Aug. 29, 1880	VII, 89

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† Date of death unknown.

Name	Date of Election	Date of Death	Memoirs*
Gridley, Vernon Hill	J. Feb. 4, 1896	Sept. 17, 1896	*XXXVI, 595*
Griffen, John	M. April 15, 1868	Jan. 14, 1884	XII, 38
Griffin, Eugene	M. June 7, 1899	April 10, 1907	....
Guild, Josephus Conn	M. June 1, 1898	Feb. 25, 1907	*LIX, 540*
Gurnee, Walter S	F. May 10, 1870	April 17, 1903	....
Gzowski, *Sir* Casimir Stanislaus	M. Dec. 2, 1868	Aug. 24, 1898	*XLII, 567*
Haddock, Arba Read	A. May 4, 1881	Feb. 28, 1885	XIX, 67
Hadsall, Joseph Canby	A. M. Nov. 8, 1909	June 29, 1911	....
Hague, Charles Arthur	M. Feb. 3, 1892	June 25, 1911	....
Haines, Frank March	M. Mar. 1, 1905	June 1, 1905	....
Hall, George Thomas	A. 1872 M. Sept. 2, 1874	June 2, 1881	VII, 97
Hamlin, Charles Edward	A. Jan. 2, 1894	Jan. 20, 1902	....
Handy, Edward Adino	M. Jan. 2, 1889	Nov. 21, 1907	....
Hannaford, Edmund Phillips	M. Sept. 18, 1872	Aug. 19, 1902	....
Harbaugh, Springer	F. May 19, 1871	Dec. 8, 1887	XV, 46
Hardee, Thomas Sydenham	M. April 4, 1877	May 20, 1880	XII, 66
Harding, Henry	M. May 7, 1873	Oct. 23, 1910	*LXXII, 591*
Harding, Horace	M. Nov. 2, 1892	July 29, 1899	*XLIII, 618*
Hardy, George Richardson	M. Nov. 7, 1888	April 2, 1903	....
Harper, John Bradford	M. Oct. 4, 1905	Mar. 24, 1908	....
Harris, Charles Marshall	A. Jan. 8, 1873	Oct. 28, 1909	....
Harris, Henrique	M. Dec. 3, 1873	Oct. 10, 1882	*XXXVII, 562*
Harris, Robert Lewis	M. May 3, 1876	Sept. 29, 1896	....
Harrison, Stephen A	F. Jan. 30, 1873	June 6, 1898	....
Harrod, Thomas	J. Dec. 3, 1891	Dec. 31, 1896	....
Hasbrouck, Charles Alfred	A. M. 1892 M. Dec. 5, 1894	Feb. 1, 1910	*LXX, 473*
Hasell, Bentley Douglas	M. July 3, 1878	May 29, 1900	....
Hasie, Montague Sylvester	M. Feb. 3, 1897	May 30, 1907	....
Haskell, Charles Frederic Beales	M. Oct. 7, 1891	May 20, 1895	XXI, 181
Haslett, Sullivan	M. June 4, 1879	Jan. 4, 1887	XIII, 127
Haswell, Charles Haynes	M. 1868 H. M. May 12, 1905	May 12, 1907	*LXI, 553*
Hatfield, Robert G	M. Dec. 4, 1867	Feb. 15, 1879	*XXXVI, 558*
Hausman, Frederick Appel	J. Feb. 3, 1903	Mar. 6, 1906	*LVII, 533*
Hawes, Louis Edwin	A. M. Sept. 2, 1896	Jan. 29, 1911	*LXXIII, 508*
Hawkins, Irving	A. M. May 6, 1908	Mar. 14, 1911	*LXXIV, 523*
Hawkshaw, *Sir* John	H. M. Nov. 3, 1880	June 2, 1891	XVII, 250
Haycroft, James Isaac	A. M. Jan. 3, 1894	April 11, 1908	*LXII, 564*
Hayes, Richard Somers	M. Sept. 6, 1882	Mar. 2, 1905	*LV, 448*
Hayward, James A	M. Sept. 5, 1877	Aug. 13, 1880	VII, 88
Hazen, Richard	J. Nov. 8, 1909	Aug. 13, 1911	....
Hegeman, Allen Bogardus	M. Feb. 1, 1888	Oct. 22, 1892	XIX, 171
Hemming, Dunkin Wirgman	A. M. 1892 M. May 31, 1904	Mar. 22, 1906	*LIX, 543*
Henry, Daniel Farrand	M. July 7, 1875	May 13, 1907	*LXXI, 420*
Hequembourg, Charles Ezra	M. June 5, 1901	Oct. 17, 1907	*LIX, 545*
Hermany, Charles	M. Jan. 6, 1869	Jan. 18, 1908	*LXV, 525*
Hildenbrand, Wilhelm	M. Feb. 5, 1902	Feb. 21, 1908	....
Hildreth, Russell Wadsworth	J. Jan. 4, 1888	Dec. 23, 1895	*XXXVI, 596*
Hilgard, Julius Erasmus	M. July 10, 1872	May 8, 1891	XVIII, 189
Hillman, Charles La Fletcher	M. July 5, 1876	June 14, 1902	*XLIX, 345*
Hilton, George Porter	M. May 1, 1889	Oct. 7, 1909	....
Hinckley, John Franklin	M. May 6, 1885	Feb. 20, 1911	*LXXIII, 504*
Hislop, John	M. May 1, 1895	Feb. 22, 1901	....
Hite-Smith, Van Dusen	A. M. April 3, 1901	Aug. 27, 1905	*LVI, 479*
Hjortsberg, Maximilian	M. July 10, 1872	May 16, 1880	VIII, 118
Hobby, Arthur Stanley	M. June 6, 1894	May 28, 1902	*XLIX, 347*
Hoe, Richard March	M. Oct. 1, 1873	June 8, 1886	XVI, 170
Holbrook, Henry Randolph	M. Jan. 2, 1890	Dec. 21, 1907	*LXXIII, 506*
Holley, Alexander Lyman	M. Oct. 1, 1873	Jan. 29, 1882	XVI, 212
Holmes, Edwin Merritt	J. 1903 A. M. Jan. 2, 1907	Feb. 11, 1911	*LXXII, 598*
Horan, John Joseph	A. M. Oct. 7, 1908	Nov. 9, 1909	*LXVII, 634*
Houston, John	M. May 6, 1868	Aug. 30, 1896	*XXXIX, 694*
Howe, Horace Joseph	J. 1888 M. Mar. 2, 1898	Jan. 21, 1911	*LXXIV, 502*
Howe, Milton Grosvenor	M. Oct. 16, 1872	June 19, 1902	*XLIX, 349*
Howell, Charles W	M. Mar. 3, 1875	April 5, 1882	VIII, 121
Howell, George Washington	M. May 2, 1888	Feb. 15, 1901	*XLIX, 351*
Howland, George, Jr	F. June 6, 1870	Feb. 18, 1892	XX, 154
Humphrey, Henry Cyprian	A. M. 1901 M. Oct. 3, 1905	Dec. 7, 1909	*LXVII, 630*
Humphrey, William Sheldon	A. M. Sept. 2, 1891	April 18, 1895	XXI, 98
Humphreys, Andrew Atkinson	H. M. May 7, 1873	Dec. 27, 1883	XVI, 218
Humphreys, Charles	M. Feb. 1, 1905	Nov. 18, 1906	*LVIII, 534*
Hunt, Alfred Ephraim	M. Sept. 1, 1886	April 26, 1899	*XLVI, 557*
Hunt, Randell	M. May 2, 1883	Jan. 24, 1898	*XLV, 629*
Huntington, Collis Potter	F. Mar. 10, 1877	Aug. 13, 1900	....

DECEASED H-L

Name	Date of Election	Date of Death	Memoirs*
Hutton, Nathaniel Henry	M. June 3, 1896	May 8, 1907	*LX, 581*
Hutton, William Rich	M. Jan. 8, 1873	Dec. 11, 1901	....
Hyde, William Birelie	M. July 12, 1877	June 8, 1882	XVI, 172
Irwin, Roger Brooke	A. M. May 3, 1910	May 23, 1910	*LXXI, 448*
Ives, Edward Bernard	M. April 5, 1893	Dec. 30, 1903	....
Jackson, Jones Mumford	M. Sept. 1, 1886	Aug. 31, 1906	....
Jackson, William	M. Sept. 3, 1884	June 30, 1910	*LXXIV, 504*
James, John Collinson	M. Mar. 1, 1876	Feb. 27, 1883	XVI, 164
Jennings, Henry Clay	M. April 6, 1887	Mar. 13, 1894	XX, 88
Jennings, William Tyndale	M. April 2, 1884	Oct. 24, 1906	....
Jervis, John Bloomfield	M. 1867 H. M. 1868 F. Mar. 19, 1880.	Jan. 12, 1885	XI, 109
Jewett, William Bradford	J. June 4, 1891	Nov. 7, 1894	XX, 202
Johnson, Archibald	M. April 6, 1898	Oct. 3, 1899	....
Johnson, Charles Roberts	M. June 3, 1885	Sept. 11, 1893	XX, 45
Johnson, John Butler	M. April 7, 1886	June 23, 1902	*LI, 454*
Johnson, Lorenzo Medici	J. 1875 M. April 7, 1880	Nov. 28, 1904	....
Johnson, Luther Elman	J. Sept. 6, 1904	Mar. 23, 1910	*LXX, 480*
Johnson, T. Marr	M. Feb. 26, 1872	July 31, 1874	I, 171
Johnson, Wallace Clyde	M. Oct. 5, 1892	Dec. 15, 1906	*LVIII, 538*
Johnston, Andrew Langstaff	M. June 4, 1890	May 15, 1901	....
Jones, Benjamin Franklin	F. June 13, 1870	May 19, 1903	....
Jones, Washington	M. Oct. 7, 1874	July 30, 1910	....
Jordan, Gabriel	M. Sept. 18, 1872	Nov. 10, 1884	XVI, 184
Joy, James Frederic	F. Nov. 6, 1872	Sept. 24, 1896	*XXXVII, 575*
Judah, Theodore Dehone	M. May 4, 1853	Nov. 2, 1863	*XXXVIII, 448*
Keefer, Samuel	M. Jan. 6, 1869	Jan. 9, 1890	XVI, 220
Kellogg, Albert Victor	A. M. Nov. 6, 1895	Feb. 15, 1911	*LXXIII, 510*
Kenly, Edward Marion	M. May 4, 1904	June 10, 1911	*LXXIV, 506*
Kenyon, George Cecil	A. M. 1900 M. June 6, 1905	Oct. 30, 1906	....
Kernot, William Charles	M. Mar. 6, 1889	Mar. 14, 1909	*LXVI, 499*
Killebrew, Samuel	M. Sept. 2, 1885	Jan. 9, 1899	*XLI, 639*
King, Charles Cyrus	M. Sept. 2, 1891	Jan. 13, 1911	*LXXII, 592*
Kingman, Lewis	M. July 1, 1885	†	....
Kingsley, William C	M. June 6, 1870	Feb. 21, 1885	*XXXVI, 612*
Kinney, Edward Cornelius	M. May 3, 1882	Jan. 16, 1910	....
Kirkwood, James Pugh	M. Nov. 5, 1852	April 22, 1877	IV, 60
Kloman, Andrew	F. Jan. 27, 1875	Dec. 19, 1880	VII, 122
Knight, William Baker	J. 1875 M. Jan. 7, 1880	Dec. 7, 1890	XVII, 277
Knowlton, Charles Andrews	M. Oct. 2, 1901	Mar. 2, 1903	*LV, 451*
Krupp, Alfred	F. June 14, 1870	July 14, 1887	*XXXVI, 609*
Lane, Moses	M. Dec. 4, 1867	Jan. 25, 1882	XIX, 58, 101
Lassig, Moritz	M. April 2, 1884	Jan. 7, 1902	*XLIX, 353*
Latcha, Jacob Albert	M. May 7, 1873	Nov. 30, 1904	*LIV, 531*
Latham, Norman Smith	J. July 3, 1889	Nov. 10, 1903	*LIV, 542*
Latimer, Charles	M. April 5, 1876	Mar. 25, 1888	XV, 137
Latrobe, Charles Hazlehurst	M. Nov. 16, 1870	Sept. 19, 1902	....
Laurie, James	M. Nov. 5, 1852	Mar. 16, 1875	*XXXVII, 553*
Lavalle, Louis Ralph	A. M. Feb. 1, 1905	Nov. 15, 1905	....
Law, Arthur Price	A. M. June 3, 1903	Nov. 19, 1906	*LVIII, 547*
Lawler, John	F. April 28, 1883	Feb. 23, 1891	....
Lawson, William Bateman	M. Feb. 1, 1893	Jan. 27, 1901	*XLVI, 560*
Lawton, Frederick Beecher	J. 1891 A. M. Nov. 4, 1896	Oct. 13, 1897	....
Leather, Basil Henry	A. June 1, 1904	Oct. 31, 1911	*LXXIV, 527*
Lederle, George Anthony	J. 1883 M. Oct. 6, 1886	Mar. 27, 1905	*LXXI, 423*
Lee, George William	J. 1902 A. M. Jan. 2, 1907	Jan. 6, 1911	....
Leers, Frank Adolph	M. May 4, 1887	May 19, 1890	XX, 85
Lesage, Louis	M. Sept. 7, 1881	Jan. 9, 1889	XVI, 96
Leutzé Trevor McClurg	M. Feb. 3, 1897	Oct. 14, 1901	....
Leverich, Gabriel	M. July 6, 1870	Nov. 28, 1905	*LVI, 469*
Lewerenz, Alfred Courtney	1895 A. M. 1900 M. Mar. 6, 1906	May 27, 1911	*LXXIV, 508*
Lewis, Isaiah William Penn	M. Jan. 5, 1853	Oct. 18, 1856	*XXXVIII, 453*
Lewis, James Frederick	A. Feb. 6, 1889	July 23, 1901	....
Libby, Edmund Dorman	M. May 6, 1885	April 24, 1903	*LXXI, 424*
Lincoln, William Shattuck	M. Dec. 5, 1883	May 16, 1902	*LI, 457*
Lindenberger, Cassius Howard	A. Feb. 2, 1892	Jan. 5, 1905	....
Lindenthal, Dominik	A. M. Mar. 4, 1896	June 7, 1900	*XLV, 637*
Linville, Jacob Hays	M. Mar. 3, 1875	Aug. 4, 1906	*LIX, 549*
Livingston, Julius I.	A. July 3, 1889	Mar. 1, 1910	....
Locke, Augustus Woodbury	M. June 7, 1882	May 14, 1893	XIX, 172

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† Date of death unknown.

Name	Date of Election	Date of Death	Memoirs*
Lockwood, John	A. April 5, 1882	Dec. 9, 1891	XVIII, 192
Lofland, Henry Fiddeman	M. June 2, 1897	Jan. 14, 1912	....
Lombardo, Javier Diaz	A. M. Oct. 2, 1907	Mar. 22, 1911	....
Long, Dennis	F. Mar. 28, 1872	Oct. 8, 1893	....
Long, Thomas John	J. 1875 M. Jan. 7, 1880	Nov. 20, 1905	....
Looker, Henry Brigham	A. M. May 3, 1893	Jan. 3, 1905	*LVIII, 548*
Lord, Harold	J. Sept. 3, 1907	†	....
Lotz, William Herman	M. Sept. 1, 1875	Jan. 31, 1894	XX, 74
Lovecraft, Frederick Aaron	F. Nov. 1, 1892	Oct. 26, 1893	....
Lovett, Thomas Davis	M. May 3, 1871	Dec. 5, 1897	*XL, 571*
Lowe, Gorham Parsons	M. April 21, 1869	Jan. 8, 1894	XX, 72
Lowrie, Harvey Childs	M. Mar. 2, 1892	Mar. 26, 1911	....
Lowthorp, Francis C	M. 1868 F. Mar. 17, 1870	June 1, 1890	XX, 196
Ludlow, William	M. July 5, 1882	Aug. 30, 1901	....
Lusk, James Loring	M. Mar. 4, 1891	Sept. 25, 1906	....
Lydston, Walter Edward	J. April 4, 1905	May 8, 1910	....
Lyon, William M	F. Mar. 23, 1870	July 3, 1889	XVI, 112
Lyte, Francis Asbury	A. M. Oct. 5, 1892	June 24, 1896	*XXXVIII, 461*
Macfarlane, Arthur Keddie	J. Oct. 5, 1909	Nov. 1, 1910	*LXXII, 599*
MacHarg, William Storrs	M. Dec. 2, 1903	May 6, 1910	....
Mackall, Benjamin Franklin	M. Mar. 6, 1901	April 5, 1911	*LXXIV, 511*
Maclennan, John Donald	M. Oct. 4, 1899	Feb. 26, 1907	....
MacLeod, John	M. July 10, 1872	Jan. 21, 1900	....
MacNaughton, James	M. May 5, 1880	Dec. 29, 1905	*LVI, 471*
MacRitchie, Charles	A. 1872 M. April 5, 1876	Jan. 27, 1909	*LXIV, 587*
Macy, Arthur	J. 1877 M. Dec. 2, 1885	April 14, 1891	*XXXVII, 562*
McAlpine, Charles LeGrand	M. Dec. 4, 1867	Jan. 11, 1884	*XXXVII, 563*
McAlpine, William Jarvis	M. 1853 H. M. Oct. 26, 1888	Feb. 16, 1890	XVIII, 115
McBee, Vardry Echols, Jr	A. M. Oct. 7, 1908	June 20, 1910	*LXXI, 449*
McCalla, Richard Calvin	J. 1890 A. M. 1891 M. Dec. 5, 1894	June 13, 1904	*LV, 453*
McCurdy, John Egbert	M. April 1, 1896	Dec. 15, 1908	*LXXI, 426*
McGee, Van Norman	A. M. June 6, 1900	Sept. 28, 1904	*LIV, 538*
McGrath, Wallace	M. Sept. 5, 1883	Dec. 5, 1909	....
McKay, John Edwards	M. July 5, 1893	May 13, 1910	....
McKean, Reginald	A. M. May 2, 1894	Oct. 15, 1901	*XLIX, 366*
McKeown, Thomas	M. Dec. 3, 1879	June 7, 1904	*LXXI, 428*
McLaughlin, John Joseph	M. Nov. 1, 1893	Jan. 19, 1911	....
McNair, Thomas Speer	M. July 2, 1873	July 25, 1901	....
McVean, John Jay	M. Sept. 3, 1884	Aug. 21, 1910	*LXXI, 430*
Mahan, Dennis Hart	H. M. Mar. 2, 1853	Sept. 16, 1871	XIX, 161
Malézieux, Emile	H. M. Nov. 3, 1880	May 20, 1885	*XXXVI, 524*
Mann, George Edward	M. Sept. 3, 1884	Oct. 2, 1897	....
Mansfield, Martin William	M. July 5, 1882	Sept. 25, 1908	*LXIII, 431*
Manter, Ralph Barton	A. M. June 1, 1904	Feb. 2, 1911	....
Marden, Henry Herman, Jr	M. May 1, 1901	†	....
Marindin, Henry Louis	M. May 7, 1884	Mar. 25, 1904	....
Marr, George Anson	M. Oct. 3, 1883	Mar. 24, 1905	*LV, 454*
Marshall, Charles Alfred	M. Oct. 1, 1884	May 31, 1889	XVI, 99
Marsland, Edward	M. Feb. 6, 1878	June 25, 1898	....
Martin, Charles Cyril	M. July 10, 1872	July 11, 1903	....
Martin, Robert Kirkwood	M. June 1, 1892	Nov. 24, 1893	XX, 43
Mason, Eddy D	M. 1872 F. Dec. 28, 1872	Dec. 19, 1874	I, 329
Matcham, Charles Arthur	M. June 5, 1901	Sept. 22, 1911	*LXXIV, 513*
Mayer, August	A. M. June 1, 1892	Mar. 25, 1909	....
Meier, William	A. M. June 1, 1909	Feb. 14, 1910	*LXVIII, 485*
Melcher, Frank Otis	M. Mar. 3, 1897	Jan. 22, 1912	....
Mendell, George Henry	M. Sept. 6, 1876	Oct. 19, 1902	*LI, 459*
Menocal, Aniceto Garcia	M. Feb. 3, 1875	July 20, 1908	....
Mercur, Frederick	M. July 20, 1870	Jan. 17, 1888	XVII, 157
Meriwether, Niles	M. Nov. 1, 1871	Dec. 28, 1900	*XLV, 632*
Merrill, William Emery	M. Oct. 6, 1872	Dec. 14, 1891	XVIII, 90
Merz, Frederick W	F. May 28, 1872	Dec. 8, 1883	*XXXVI, 615*
Mesa, Antonio Esteban	A. M. Jan. 1, 1896	Feb. ‡ 1911	....
Metcalf, William	M. July 2, 1873	Dec. 5, 1909	*LXXIV, 490*
Meyer, Thomas C	M. Dec. 7, 1852	Jan. 26, 1908	....
Michaelis, Otho Ernest	M. May 6, 1874	May 1, 1890	XVII, 132
Michie, William Roberts	J. 1893 A. M. Oct. 7, 1896	Feb. 2, 1899	*XLI, 647*
Miller, Alexander Macomb	M. June 6, 1888	Sept. 14, 1904	....
Miller, Samuel H	M. Sept. 6, 1882	Mar. 18, 1891	XVII, 208
Miller, Silvanus, Jr	M. Mar. 2, 1887	Dec. 17, 1897	*XXXIX, 696*
Mills, James Ellison	M. Feb. 3, 1886	July 25, 1901	....
Milne, Peter	A. Jan. 7, 1896	June 9, 1902	....
Minturn, Rowland Robinson	M. Nov. 2, 1887	April 7, 1898	....

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† Date of death unknown.

‡ Exact date of death unknown.

DECEASED *M*-P

Name	Date of Election	Date of Death	Memoirs*
Mitchell, Alexander	F. June 13, 1883	April 19, 1887	XIII, 98
Mitchell, Henry	M. Jan. 7, 1880	Dec. 1, 1902	....
Mitchell, Stephen Arnold	M. Oct. 2, 1907	May 21, 1908	*LXII, 552*
Moffet, James David	A. M. 1891 M. Feb. 7, 1894	Nov. 3, 1899	....
Monroe, John Albert	M. Sept. 4, 1869	June 11, 1891	XIX, 148
Montony, Liberty Gilbert	J. 1892 A. M. Feb. 5, 1896	Oct. 20, 1909	....
Morison, George Shattuck	M. Jan. 6, 1875	July 1, 1903	*LIV, 513*
Morison, William Smith	A. M. April 6, 1904	May 1, 1905	....
Morley, James Henry	M. Oct. 6, 1886	Sept. 8, 1889	XVI, 110
Morley, William Raymond	M. Sept. 6, 1882	Jan. 3, 1883	IX, 121
Morrell, William H	M. Nov. 5, 1852	†	....
Morris, Gouverneur	M. Oct. 3, 1888	Dec. 30, 1897	*XXXIX, 698*
Morris, Robert Campbell	M. Jan. 7, 1874	Nov. 8, 1892	XVIII, 220
Morris, William W	M. Jan. 5, 1853	†	....
Morse, Henry Grant	M. April 7, 1880	June 2, 1903	....
Morse, James Otis	M. Feb. 9, 1853	Mar. 8, 1883	XIX, 47
Morton, Charles	M. Oct. 2, 1895	Aug. 28, 1909	....
Morton, John Henry	M. June 3, 1891	Feb. 8, 1892	XVIII, 105
Moulton, Mace	M. June 4, 1884	April 27, 1909	....
Murakami, Kyoichi	M. Sept. 4, 1901	Aug. 18, 1906	....
Murdoch, Gilbert	M. Sept. 7, 1881	May 28, 1894	XX, 152
Myers, Edmund Trowbridge Dana	M. May 2, 1888	May 12, 1905	....
Myers, George Higgins	J. June 1, 1909	Oct. 10, 1910	*LXXI, 454*
Myers-Beswick, William Beswick	M. Jan. 3, 1894	Dec. 27, 1904	*LIV, 534*
Neilson, Robert	M. Feb. 17, 1869	Oct. 12, 1896	*XXXVII, 564*
Nelles, George Thomas	M. Oct. 3, 1888	Nov. 15, 1907	*LX, 586*
Newell, John	M. Jan. 29, 1868	Aug. 26, 1894	XX, 172
Newham, Charles Edward	M. Dec. 7, 1887	Feb. 1, 1898	....
Newton, Isaac	M. Mar. 3, 1880	Sept. 25, 1884	XI, 128
Newton, John	H. M. April 30, 1884	May 1, 1895	....
Nichols, Norman James	M. Dec. 5, 1888	April 8, 1896	*XXXVI, 559*
Nichols, Othniel Foster	M. June 7, 1876	Feb. 4, 1908	*LXI, 564*
Nicholson, George Benson	M. May 1, 1878	Dec. 2, 1906	*LIX, 556*
Nickerson, Louis H	M. Sept. 18, 1872	May 6, 1877	....
Norman, George H	M. 1869 F. Mar. 23, 1870	Feb. 4, 1900	....
North, Edward P	M. Dec. 4, 1867	July 20, 1911	....
Northrup, Herbert Franklin	M. Jan. 6, 1892	Jan. 21, 1908	*LX, 588*
Norton, Frederick Oakford	F. June 4, 1879	Sept. 27, 1892	XVIII, 219
Norton, John Talcott	M. Nov. 3, 1897	Aug. 5, 1905	....
Nourse, Edwin Green	M. Sept. 3, 1884	Dec. 8, 1897	*XXXIX, 699*
Noyes, Albert Franklin	M. Dec. 3, 1884	Oct. 12, 1896	*XXXVI, 560*
Oberndorf, Paul Ernest	J. Feb. 5, 1907	Oct. 13, 1907	*LX, 595*
Ogden, William B	F. Mar. 23, 1870	Aug. 3, 1877	IV, 67
Olney, Robert Blum	J. 1895 A. M. Sept. 5, 1900	Mar. 4, 1903	*L, 510*
O'Melveny, John Charles	M. May 4, 1898	Oct. 3, 1899	....
O'Sullivan, Thomas S	M. Jan. 5, 1853	Nov. 1, 1855	....
Paddock, Joseph Hill	M. Oct. 5, 1892	April 4, 1894	XX, 89
Paine, Charles	M. Dec. 4, 1867	July 4, 1906	*LX, 575*
Paine, William Henry	M. May 12, 1875	Dec. 31, 1890	XVII, 160
Palmer, Cornelius	M. Nov. 2, 1887	July 31, 1903	....
Parker, Charles Francis	J. Mar. 5, 1890	Oct. 10, 1898	....
Parker, William	M. Mar. 7, 1900	Sept. 30, 1909	....
Parkhurst, Henry Williams	M. Sept. 5, 1877	April 7, 1906	....
Patch, Homer Austin	A. M. Jan. 8, 1908	April 4, 1911	....
Patterson, John Austin	M. May 2, 1900	May 3, 1903	....
Pearson, William Anson, Jr	M. Sept. 6, 1905	May 26, 1908	*LXXI, 431*
Pearsons, Galen W	M. Jan. 6, 1875	Aug. 19, 1907	....
Pennypacker, Levis Passmore	A. M. April 1, 1891	Jan. 30, 1901	*XLVI, 570*
Perrine, Frederic Auten Combs	M. May 3, 1905	Oct. 20, 1908	....
Petry, Alfred	M. Oct. 6, 1886	May 14, 1901	....
Philbrick, Edward Southwick	M. May 6, 1874	Feb. 13, 1889	*XXXVIII, 454*
Phillips, William	F. Mar. 23, 1870	April 14, 1874	I, 169
Phinney, Henry Ward Beecher	M. Jan. 7, 1885	Nov. 22, 1888	*XXXVI, 563*
Pierce, Henry	M. Dec. 5, 1894	Aug. 21, 1911	....
Pierce, William Thomas	M. May 6, 1896	Feb. 26, 1906	*LVII, 525*
Pike, William Abbot	M. Dec. 3, 1890	Oct. 13, 1895	XXI, 212
Platt, Joseph Curtis	M. July 2, 1895	July 7, 1898	....
Plympton, George Washington	M. Jan. 29, 1868	Sept. 11, 1907	....
Poe, Orlando Metcalf	M. Jan. 8, 1873	Oct. 2, 1895	....

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† Date of death unknown.

Name	Date of Election	Date of Death	Memoirs*
Poinier, P. Porter	J. Mar. 3, 1875	June 11, 1876	IV, 74
Pope, Macy Stanton	A. M. May 2, 1900	Dec. 10, 1904	*LIV, 540*
Pope, Willard Smith	M. Aug. 7, 1872	Oct. 10, 1895	*XXXVI, 565*
Porter, Albert Howell	J. 1888 A. M. July 1, 1891	Aug. 9, 1899	....
Post, Andrew Jackson	M. Nov. 1, 1871	Mar. 12, 1896	....
Post, James Clarence	M. Feb. 6, 1878	Jan. 6, 1896	*XXXVI, 569*
Post, Simeon S.	M. Nov. 5, 1852	June 29, 1872	XIX, 49
Potts, Joseph Dilwyn	M. Aug. 5, 1868	Dec. 3, 1893	XX, 49
Potts, Richard	M. June 1, 1870	July 11, 1891	XVII, 242
Powell, Charles Francis	M. Oct. 3, 1888	July 30, 1907	*LXI, 567*
Poynor, David Ashley	M. June 1, 1892	May 29, 1906	....
Pratt, Thomas Willis	M. 1853 F. Nov. 4, 1870	July 17, 1875	I, 332
Pratt, William Arthur	M. Dec. 4, 1895	Sept. 19, 1904	....
Prendergast, Francis Ensor	M. Mar. 7, 1888	Dec. 7, 1897	*XXXIX, 701*
Prevost, Sutherland Mallet	M. Jan. 6, 1875	Sept. 30, 1905	....
Price, Philip M.	M. May 2, 1888	Oct. 4, 1894	XX, 200
Prince, Edward	J. 1878 M. Nov. 1, 1882	Dec. 12, 1908	....
Probasco, Samuel R.	M. Nov. 18, 1868	Jan. 19, 1910	....
Prosser, Thomas	M. Dec. 4, 1867	Sept. 15, 1870	*XXXVI, 564*
Prosser, Thomas	F. June 1, 1870	Jan. 6, 1896	....
Putnam, Joseph W.	A. Mar. 3, 1880	Mar. 24, 1893	XX, 87
Quinette de Rochemont, *Baron* Emile Theodore	M. Jan. 3, 1894	Dec. 8, 1908	....
Quinlan, George Austin	M. Oct. 4, 1893	Aug. 29, 1901	....
Rafter, George W.	M. April 2, 1884	Dec. 29, 1907	*LXII, 554*
Randolph, James Lingan	M. Mar. 1, 1882	Sept. 17, 1888	XVIII, 217
Raymond, Thomas Laidlaw	M. Oct. 6, 1897	Nov. 15, 1901	*XLIX, 354*
Reece, Benjamin	M. Mar. 2, 1881	Dec. 17, 1901	....
Reed, Edward M.	M. July 10, 1872	Feb. 13, 1892	XVIII, 94
Reed, Henry Wadsworth	M. Jan. 6, 1886	Oct. 26, 1900	....
Reed, Samuel Benedict	M. Oct. 20, 1869	Dec. 25, 1891	XVIII, 183
Reed, William Ward	F. Dec. 20, 1872	Jan. 10, 1904	*LII, 558*
Rees, William Marshall	M. Oct. 4, 1905	Dec. 4, 1905	*LVI, 473*
Reeves, Samuel J.	M. April 5, 1868	Dec. 15, 1878	V, 93
Reinholdt, Kenneth Oake Plummer	J. 1894 A. M. Oct. 7, 1896	Feb. 6, 1902	*XLIX, 368*
Reiseger, Marc John	M. Dec. 7, 1898	May 26, 1900	*XLV, 634*
Reno, James Hart	M. Nov. 5, 1879	Aug. 5, 1881	*XXXVII, 566*
Rhodes, Benjamin	M. April 5, 1882	Aug. 12, 1894	XX, 163
Rhys-Roberts, Edmund Alyth	A. M. Nov. 3, 1897	Oct. 5, 1909	....
Rice, Edward Curtis	M. April 7, 1875	April 21, 1898	*XXXIX, 703*
Rice, Lewis Frederick	M. Jan. 2, 1889	April 13, 1909	....
Rich, Watson Wellman	M. Sept. 5, 1883	Jan. 12, 1903	*L, 501*
Richards, Joseph Ruggles	A. Feb. 4, 1880	Sept. 28, 1900	*XLV, 640*
Richardson, B. Frank	M. July 1, 1885	April 18, 1904	....
Richardson, Clinton Leroy	J. 1902 A. M. Oct. 2, 1907	July 7, 1910	....
Richardson, Henry Brown	M. May 7, 1879	Aug. 21, 1909	*LXVI, 501*
Riffle, Albert Stanley	M. May 7, 1890	Oct. 28, 1909	*LXVI, 504*
Rinecker, Francis	M. Aug. 7, 1872	April 10, 1899	*XLII, 569*
Rives, Alfred L.	M. Sept. 4, 1872	Feb. 27, 1903	....
Roberts, Evelyn Pierrepont	M. May 7, 1884	Dec. 30, 1910	*LXXII, 593*
Roberts, William	A. June 4, 1884	Dec. 28, 1907	*LX, 593*
Roberts, William Milnor	M. Sept. 21, 1870	July 14, 1881	*XXXVI, 531*
Robinson, George Henry	M. Mar. 7, 1888	July 4, 1906	....
Robinson, Moncure	H. M. July 6, 1853	Nov. 10, 1891	XVIII, 84
Robinson, Stillman Williams	M. Jan. 2, 1884	Oct. 31, 1910	*LXXI, 433*
Roebling, John Augustus	M. Dec. 2, 1868	July 22, 1869	....
Rogers, Albert Brainerd	M. June 6, 1883	May 4, 1889	XVI, 98
Rogers, Fairman	M. May 7, 1873	Aug. 22, 1900	....
Rogers, John Benjamin	M. Aug. 4, 1873	April 1, 1874	I, 168
Rogers, Merritt Harrison	M. Jan. 2, 1890	May 3, 1907	*LIX, 562*
Rohnert, Benno	J. April 3, 1889	Sept. 1, 1906	*LVIII, 557*
Rosecrans, William Starke	M. July 5, 1882	Mar. 11, 1899	....
Rosenzweig, Alfred	J. 1882 M. Jan. 4, 1893	Jan. 13, 1904	....
Rosewater, Andrew	M. Oct. 3, 1883	April 17, 1909	....
Rothwell, Richard Pennefather	M. Jan. 29, 1868	April 17, 1901	....
Rowe, Robert Delos	M. Jan. 2, 1890	Mar. 14, 1899	*XLII, 571*
Rowe, Samuel McMath	M. Sept. 2, 1885	May 22, 1910	*LXXII, 594*
Rowland, Thomas Fitch	M. 1867 H. M. Dec. 20, 1899	Dec. 13, 1907	*LXII, 547*
Rudolff, Henry Frederick	M. Jan. 6, 1886	June 1, 1895	*XXXVI, 570*
Rumsey, Bronson C.	F. May 12, 1870	†	....
Rusling, George McCracken	M. Nov. 1, 1882	Feb. 26, 1901	....
Russell, Nathaniel Edwards	M. Oct. 3, 1888	Jan. 14, 1902	*XLIX, 355*

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† Date of death unknown.

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Name	Date of Election	Date of Death	Memoirs*
St. John, Isaac Munroe	M. July 14, 1871	April 7, 1880	*XXXVI, 571*
Sample, John Henderson	M. Oct. 6, 1886	Mar. 4, 1910	*LXX, 474*
Sanderson, James Gardner	M. July 6, 1881	Nov. 15, 1909	....
Schaub, Julius William	J. 1884 M. Oct. 6, 1886	Mar. 30, 1909	....
Schermerhorn, Louis Younglove	M. May 5, 1897	April 3, 1908	....
Scherzer, Albert John	M. Jan. 6, 1886	Feb. 3, 1908	*LXXIV, 515*
Scherzer, William	M. Sept. 5, 1888	July 20, 1893	XX, 58
Schofield, Mark William	M. May 1, 1907	Nov. 27, 1908	*LXIII, 432*
Schott, Charles Ridgely	M. April 1, 1874	July 9, 1878	IV, 128
Schuyler, Howard	M. June 7, 1882	Dec. 3, 1883	*XXXVI, 572*
Schwitzer, John Edward	M. July 10, 1907	Jan. 23, 1911	....
Scott, William Lawrence	F. July 7, 1870	Sept. 19, 1891	XVII, 285
Scott, William Ulysses	A. M. Feb. 3, 1897	Sept. 26, 1898	*XLII, 572*
Scowden, Theodore Ransom	M. May 7, 1873	Dec. 31, 1881	....
Sears, Alfred Francis	M. June 2, 1869	June 7, 1911	....
Sears, Walter Herbert	M. Oct. 5, 1904	Oct. 7, 1911	....
Seaton, William, Jr.	A. M. June 4, 1902	Jan. 18, 1908	....
Seaver, John Wright	M. Nov. 6, 1901	Jan. 14, 1911	*LXXII, 596*
Seely, Thomas Jennings	M. Feb. 1, 1882	Oct. 2, 1883	*XXXVI, 574*
Seitzinger, William White	J. Oct. 2, 1889	Sept. 21, 1900	....
Sellers, Coleman	M. May 3, 1876	Dec. 28, 1907	....
Seymour, Horatio	A. 1873 M. April 7, 1880	Feb. 21, 1907	*LXVI, 507*
Seymour, Mark Tucker	F. July 21, 1870	May 30, 1885	*XXXVII, 578*
Shaler, Ira Alexander	J. 1888 M. June 5, 1895	June 29, 1902	*XLIX, 357*
Shanks, Thomas Pearman	M. May 2, 1888	Jan. 7, 1904	....
Shanley, James Roosevelt	A. Mar. 6, 1907	Aug. 25, 1910	....
Sheldon, Simeon	M. Feb. 5, 1873	Mar. 4, 1883	....
Shima, Takejiro	A. M. Mar. 4, 1903	Dec. 22, 1910	*LXXIV, 525*
Shinbur, Elver La Zelle	A. M. Oct. 3, 1906	Nov. 7, 1906	*LVII, 531*
Shinn, William Powell	M. Sept. 15, 1869	May 5, 1892	XVIII, 123
Shirreffs, Reuben	M. June 4, 1890	Aug. 31, 1904	....
Shreve, Samuel Henry	M. May 19, 1869	Nov. 27, 1884	*XXXVI, 576*
Sicard, Mirtiliano	M. Jan. 4, 1882	Mar. 17, 1896	*XL, 577*
Sickels, Frederick Ellsworth	M. Jan. 7, 1891	Mar. 9, 1895	*XXXVI, 577*
Sickels, Theophilus E.	M. Feb. 21, 1872	Feb. 4, 1885	XI, 130
Sidell, William H.	M. Dec. 1, 1852	July 1, 1873	I, 41
Sites, Wilmon Willets Cannon	M. Nov. 6, 1878	Oct. 1, 1885	*XXXVI, 582*
Slataper, Felician	M. Sept. 15, 1869	Sept. 11, 1906	*LVIII, 540*
Sleeper, George Edward	M. Feb. 3, 1904	Oct. 25, 1908	....
Sloan, Robert Imlay	M. Oct. 1, 1884	May 3, 1901	*XLVI, 562*
Smedley, Samuel Lightfoot	M. Sept. 2, 1874	July 21, 1894	XXI, 88
Smith, Albert Mather	M. May 5, 1886	Feb. 27, 1910	*LXX, 476*
Smith, Benjamin Burgh	M. Nov. 7, 1888	Feb. 8, 1904	*LII, 550*
Smith Charles Augustus	M. April 7, 1880	Feb. 2, 1884	XI,122
Smith, Charles C.	M. July 10, 1872	April 17, 1889	XV, 142
Smith, Charles Shaler	M. Mar. 5, 1873	Dec. 19, 1886	XIII, 105
Smith, Charles Vandervoort	M. July 5, 1876	June 30, 1884	XI, 126
Smith, David Lowber	M. May 4, 1887	Oct. 10, 1893	XX, 57
Smith, Frederick Henry	M. Feb. 21, 1872	Dec. 24, 1898	*XLI, 643*
Smith, Hamilton	M. Feb. 5, 1879	July 4, 1900	*XLVI, 564*
Smith, Isaac Williams	M. Oct. 1, 1873	Jan. 1, 1897	*XXXVIII, 456*
Smith, James	A. M. 1905 M. Mar. 31, 1908	Feb. 20, 1911	*LXXIV, 518*
Smith, Joseph Shuter	M. April 1, 1874	Mar. 26, 1907	....
Smith, Lucius A.	M. May 7, 1873	Jan. 5, 1894	XX, 48
Snyder, Francis Edward	M. Sept. 6, 1905	Dec. 23, 1905	....
Soper, Ralph Carroll	A. M. Aug. 31, 1909	June 16, 1910	*LXXI, 450*
Sosa, Pedro José	M. Dec. 3, 1884	July 4, 1898	....
Spalding, Ira	M. Aug. 2, 1870	Oct. 2, 1875	I, 338
Spencer, Samuel	M. Sept. 2, 1885	Nov. 29, 1906	....
Spielmann, Arthur	A. 1873 M. Sept. 5, 1877	Nov. 29, 1883	X, 115
Spier, Charles Louis	A. May 3, 1905	May 7, 1906	....
Spörck, Karl	M. Mar. 2, 1898	June 23, 1899	....
Sproul, Archibald Alexander, Jr.	M. May 1, 1907	April 26, 1910	*LXXI, 435*
Stahlberg, Albert Jacob	J. Mar. 4, 1874	Aug. 19, 1887	*XXXVI, 597*
Stanwood, James Hugh	A. M. Oct. 3, 1894	May 24, 1896	*XXXVI, 590*
Starling, William	M. Sept. 7, 1887	Dec. 11, 1900	*XLVI, 566*
Starr, William Wright	M. May 1, 1907	†	....
Steele, Henry Maynadier	A. M. 1893 M. Dec. 6, 1899	July 5, 1909	*LXVII, 631*
Stewart, David A.	F. Nov. 7, 1872	Dec. 14, 1888	XIX, 160
Stewart, Herbert	A. Feb. 6, 1894	Mar. 4, 1899	....
Stites, Archer Cochran	J. 1890 A. M. 1891 M. May 6, 1896	Aug. 27, 1905	*LVI, 475*
Stixrud, Martinius	M. April 3, 1889	Dec. 28, 1901	*LI, 463*
Stone, Waterman	A. Dec. 1, 1886	Mar. 30, 1896	*XLI, 649*
Storrow, Charles Storer	H. M. Jan. 24, 1893	April 30, 1904	....

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† Date of death unknown.

Name		Date of Election	Date of Death	Memoirs*
Stratton, Franklin Asa	M.	May 3, 1876	July 17, 1879	V, 96
Stratton, George Draper	A. M.	Oct. 4, 1899	Nov. 21, 1905	*LVI, 481*
Striedinger, Julius Hermann	M.	Feb. 2, 1876	Sept. 28, 1894	XX, 198
Swan, Charles Herbert	M.	Mar. 16, 1870	April 17, 1899	*XLVI, 568*
Sweesy, Thomas King	J.	Aug. 31, 1909	Sept. 2, 1911	....
Sweet, Elnathan	M.	Nov. 6, 1878	Jan. 27, 1903	....
Swift, McRee	M.	1852 F. Mar. 9, 1870	April 5, 1896	*XXXVI, 616*
Taintor, William Noyes	J.	Sept. 3, 1895	April 8, 1898	*XXXIX, 704*
Talcott, Cook	M.	April 15, 1868	Jan. 12, 1893	XIX, 99
Talcott, William Hubbard	M.	Feb. 2, 1853	Dec. 8, 1868	XIX, 97
Tallon, John Joseph	J.	Sept. 3, 1890	May ‡ 1896	....
Tasker, Charles A.	J.	Nov. 4, 1874	Oct. 4, 1879	VII, 91
Tasker, Stephen Paschall Morris	F.	Sept. 20, 1872	Mar. 19, 1900	*XLVI, 572*
Tasker, Thomas T., Jr.	F.	Jan. 7, 1873	Aug. 19, 1877	....
Tatnall, George	M.	May 3, 1899	Sept. 13, 1906	*LVIII, 544*
Taubenheim, Ulrich	A. M.	Feb. 1, 1905	Dec. 19, 1911	....
Taylor, Norman Alfred	J.	1903 A. M. Dec. 5, 1906	Aug. 29, 1910	*LXXI, 451*
Taylor, Selwyn Mellon	M.	Oct. 7, 1903	Jan. 25, 1904	*LII, 552*
Taylor, William Dana	M.	Mar. 1, 1899	Aug. 26, 1911	*LXXIV, 520*
Taylor, William Johnston	F.	May 10, 1870	Feb. 17, 1903	....
Teigen, Thomas William Rostad	J.	1905 A. M. Dec. 1, 1908	Sept. 20, 1911	....
Temple, John Frederic	J.	1890 A. M. Oct. 4, 1893	July 21, 1895	XXI, 183
Temple, Robert Henry	M.	May 6, 1885	Dec. 23, 1901	....
Terry, Edward Clinton	M.	Feb. 6, 1895	April 6, 1908	....
Thaw, William	F.	Aug. 30, 1871	Aug. 17, 1889	XVI, 100
Thayer, William Watmough	A. M.	Dec. 2, 1891	Mar. 14, 1893	XIX, 94
Thomas, Arthur Towne	M.	June 6, 1894	Oct. 10, 1900	*XLIX, 360*
Thomas, George Edward	M.	Oct. 5, 1898	Mar. 6, 1908	*LXI, 571*
Thomas, Joseph Russell	M.	Oct. 5, 1881	Nov. 28, 1896	*XXXVII, 566*
Thompson, John Chambers	M.	May 18, 1870	Jan. 17, 1880	*XXXVI, 584*
Thompson, William George McNeill	M.	July 2, 1879	May 12, 1903	....
Thomson, George Huntington	M.	Feb. 2, 1887	Feb. 7, 1910	*LXXI, 438*
Thorndike, John Larkin	M.	May 7, 1873	Oct. 12, 1901	*LX, 590*
Thorp, Richard Fenwick	A. M.	1904 M. Mar. 5, 1907	July 28, 1908	*LXXI, 442*
Thurston, Robert Henry	M.	Dec. 6, 1871	Oct. 25, 1903	....
Tidd, Marshall Martain	M.	Oct. 2, 1878	Aug. 20, 1895	*XXXVII, 568*
Tingley, George Curtis	M.	Sept. 6, 1871	April 30, 1904	*LIII, 510*
Tönnesen, Fridthjov Lauritz Martin	A. M.	June 3, 1908	Sept. 17, 1910	....
Totten, Joseph Gilbert	H. M.	Mar. 2, 1853	April 22, 1864	*XXXVI, 525*
Toucey, John Montgomery	F.	May 17, 1870	Sept. 29, 1898	*XLV, 644*
Tower, Ashley Bemis	M.	Oct. 3, 1894	July 8, 1901	*XLIX, 361*
Tracy, Edward Huntington	M.	June 13, 1868	Aug. 28, 1875	I, 337
Tracy, John F.	F.	Jan. 20, 1873	Feb. 13, 1878	IV, 71
Trafton, Gilman	M.	Jan. 4, 1871	May 25, 1887	XV, 42
Truesdell, Charles	M.	Sept. 15, 1869	April 23, 1894	*XXXVI, 585*
Tubbs, Joseph Nelson	M.	Sept. 3, 1884	Sept. 20, 1909	....
Tullock, Alonzo J.	M.	June 6, 1883	July 21, 1904	*LIV, 535*
Turner, Willis Tubbs	A. M.	Dec. 7, 1904	Sept. 7, 1911	....
Tutton, Charles Harold	M.	Oct. 2, 1901	June 19, 1908	*LXII, 560*
Tyson, Henry	M.	July 10, 1872	Sept. 1, 1877	IV, 110
Ubsdell, John Arnold	A.	June 7, 1905	April 23, 1909	....
Van der Hoek, Jacobus	M.	April 7, 1897	Dec. 22, 1909	*LXX, 477*
Vanderpool, Eugene	M.	Sept. 2, 1874	July 12, 1903	....
Van Slooten, William	M.	Nov. 3, 1897	Dec. 14, 1901	....
Vaughan, Frederic Willis	M.	Feb. 17, 1869	Oct. 19, 1887	XV, 44
Vaughn, Clarence George	M.	Nov. 7, 1906	Aug. 4, 1908	*LXII, 562*
Veazie, Joseph	M.	May 3, 1876	Mar. 2, 1897	....
Vinton, Francis Laurens	M.	Aug. 5, 1868	Oct. 6, 1879	VIII, 91
Wainwright, Jonathan	M.	Feb. 3, 1892	Oct. 11, 1907	....
Waite, Christopher Champlain	M.	Mar. 3, 1880	Feb. 21, 1896	*XLIX, 363*
Walker, George Clarke	F.	Feb. 6, 1873	April 12, 1905	....
Walker, Joseph Milton	A. M.	April 3, 1901	Jan. 7, 1908	....
Walker, William Williams	M.	Oct. 6, 1880	Sept. 23, 1893	XIX, 174
Walling, Henry Francis	M.	May 6, 1868	April 8, 1888	XV, 140
Walton, Louis Roberts	M.	April 1, 1885	Nov. 9, 1885	*XXXVI, 586*
Ward, Lebbeus Baldwin	M.	Mar. 16, 1870	July 2, 1901	....
Wardlaw, James Robert	M.	Mar. 3, 1886	Dec. 27, 1891	XVIII, 96
Ware, Reuel Willard	M.	April 1, 1874	Sept. 10, 1903	....

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‡ Exact date of death unknown.

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Warman, Frederick Conover	A. M. 1900 M. May 3, 1904	April 27, 1908	....
Watkins, John Elfreth	A. Jan. 2, 1889	Aug. 11, 1903	....
Watkins, Samuel Dale	J. Mar. 31, 1908	Sept. 7, 1911	....
Watson, William Parsons	M. June 1, 1887	Dec. 19, 1910	....
Way, Robert Attwell	M. June 7, 1893	April ‡, 1901	....
Weber, Christian Philipp Max Maria, *Baron* von	H. M. June 2, 1880	April 18, 1881	VIII, 89
Webster, Frank Wallace	A. M. May 6, 1908	Feb. 15, 1910	....
Weir, Frederic Candee	M. Aug. 7, 1872	Mar. 1, 1899	....
Welch, Ashbel	M. Aug. 7, 1872	Sept. 25, 1882	IX, 137
Weld, Frederick Floyd	M. Sept. 3, 1884	June 28, 1890	XVII, 203
Wellington, Arthur Mellen	M. May 4, 1881	May 16, 1895	XXI, 199
Wellman, David Willard	M. Oct. 5, 1870	Aug. 18, 1898	....
Wells, Clinton Glencairn	J. 1901 A. M. Mar. 1, 1905	Aug. 16, 1908	*LXIV, 590*
Wells, Daniel L.	F. June 13, 1883	Nov. 24, 1884	XI, 132
Wheaton, Edward	A. Feb. 4, 1880	Mar. 6, 1889	....
Wheeler, Orlando Belina	M. Nov. 2, 1887	June 3, 1896	*XXXVI, 587*
Whipple, Squire	H. M. May 6, 1868	Mar. 15, 1888	*XXXVI, 527*
Whitcomb, Henry Donald	M. Feb. 21, 1872	Jan. 26, 1910	....
White, George Howard	M. May 2, 1883	Dec. 29, 1911	....
White, William Howard	M. Mar. 5, 1873	Dec. 11, 1895	*XLV, 635*
Whitelaw, John	M. Feb. 5, 1873	June 16, 1892	XVIII, 191
Whitford, Oscar F.	M. Dec. 6, 1871	May 21, 1902	*XLIX, 364*
Whitman, Thomas Jefferson	M. June 29, 1868	Nov. 25, 1890	XVIII, 103
Whitney, Nelson Oliver	M. Mar. 1, 1893	Mar. 18, 1901	....
Whitten, Nathan Hollis	M. June 7, 1876	Aug. 23, 1905	....
Whitton, Andrew Dempster	M. May 6, 1891	Feb. 23, 1892	XX, 85
Wightman, Henry Morse	M. April 2, 1873	April 3, 1885	XII, 124
Wightman, Willard Humphrey	M. Sept. 5, 1888	Oct. 29, 1889	XVI, 218
Wilkins, George Shreve	J. 1892 A. M. Oct. 5, 1898	Aug. 17, 1910	....
Willard, James Eager	M. May 1, 1899	Mar. 8, 1909	*LXXI, 445*
Williams, Edward Higginson	M. Sept. 5, 1883	Dec. 21, 1899	....
Williams, Norman A.	M. Feb. 17, 1869	Oct. 12, 1879	VIII, 92
Williams, William	F. June 16, 1870	Sept. 10, 1876	....
Williamson, William Garnett	M. April 4, 1883	Aug. 2, 1898	*XLI, 645*
Wilson, Arthur Owen	M. Mar. 7, 1888	Dec. 20, 1891	XVIII, 131
Wilson, John Allston	M. June 7, 1876	Jan. 19, 1896	*XXXVI, 588*
Wilson, Joseph Miller	M. April 2, 1873	Nov. 24, 1902	*L, 504*
Wilson, William Hasell	H. M. Aug. 2, 1892	Aug. 17, 1902	....
Wilson, William Willard	M. Jan. 5, 1870	Feb. 7, 1887	XIII, 40
Wisner, George Y.	M. April 5, 1876	July 3, 1906	....
Wolkowyski, Alexander Ilich	J. Jan. 7, 1908	Sept. 27, 1910	....
Wood, Arthur Hastings	J. Mar. 31, 1891	April 2, 1892	XVIII, 106
Wood, Charles	A. M. July 4, 1894	Nov. 28, 1895	*XXXVI, 591*
Wood, Charles Widney	M. Oct. 7, 1908	April 3, 1911	*LXXIV, 522*
Woollard, George Clifton	J. April 3, 1900	June 3, 1905	*LV, 456*
Worthen, William Ezra	M. 1867 H. M. April 4, 1893	April 2, 1897	*XL, 565*
Worthington, Henry R.	M. Jan. 5, 1876	Dec. 17, 1880	....
Wright, George Francis	M. Jan. 4, 1888	Aug. 20, 1892	XVIII, 206
Wright, Horatio Gouverneur	H. M. Mar. 3, 1890	July 2, 1899	*XLVI, 551*
Wright, Joshua Butler	F. May 24, 1870	Oct. 31, 1877	....
Wright, Moses Hannibal	J. 1900 M. Sept. 3, 1902	June 8, 1906	....
Wright, William Wierman	M. Mar. 3, 1875	Mar. 9, 1882	VIII, 119
Würtele, Arthur Sheppard Campbell	M. Mar. 5, 1873	Mar. 20, 1899	....
Yeatman, Henry Clay	J. May 7, 1890	Dec. 20, 1896	*XL, 579*
Yorke, Edward	M. Nov. 1, 1882	May 28, 1884	XI, 124
Young, Eddy Elbert	A. M. Jan. 6, 1904	June 1, 1906	*LVIII, 551*
Young, Herbert Andrew	J. May 7, 1884	Dec. 8, 1894	XXI, 69
Young, William Clark	H. M. Mar. 1, 1892	Dec. 22, 1893	XIX, 192
Zeller, Albert Henry	J. 1890 A. M. April 7, 1897	Nov. 2, 1906	*LVIII, 554*
Zipperlein, Joseph William	A. June 4, 1901	July 22, 1907	*LIX, 565*

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‡ Exact date of death unknown.

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